TRANSPORT RESEARCH LABORATORY

PA3176/96

INTELLIGENT TRANSPORT SYSTEM (ITS) ARCHITECTURE

PROCEEDINGS OF A TRL INTERNATIONAL WORKSHOP 8-9 MAY 1996

Editor: DP John C. Miles
Director Public Policy, ITS Focus (UK)

First Published 1996

Transport Research Foundation Group of Companies

Transport Research Foundation (a company limited by guarantee) trading as Transport Research Laboratory. Registered in England, Number 3011746.

TRL Limited. Registered in England. Number 3142272. Registered Offices:Old Wokingham Road, Crowthorne. Berkshire, RG45 6AU.

Intelligent Transport System

(ITS) Architecture

Proceedings of a

TRL International Workshop

8-9 May 1996

Editor: Dr. C. Miles
Director Public Policy, ITS FOCUS (UK)

ITS FOCUS PA3176196

The Transport Research Laboratory is the largest and most comprehensive centre for the study of road transport in the United Kingdom. For more than 60 years it has provided information that has helped frame transport policy, set standards and save lives.

TRL provides research-based technical help which enables its Government Customers to set standards for highway and vehicle design, formulate policies on road safety, transport and the environment, and encourage good traffic engineering practice.

As a national research laboratory TRL has developed close working links with many other international transport centres.

It also sells its services to other customers in the UK and overseas, providing fundamental and applied research, working as a contractor, consultant or providing facilities and staff. TRL's customers include local and regional authorities, major civil engineering contractors, transport consultants, industry, foreign governments and international aid agencies.

TRL employs around 300 technical specialists - among them mathematicians, physicists, psychologists, engineers, geologists, computer experts, statisticians - most of whom are based at Crowthome, Berkshire. Facilities include a state of the art driving simulator, a new indoor impact test facility, a 3.8km test track, a separate self-contained road network, a structures hall, an indoor facility that can dynamically test roads and advanced computer programs which are used to develop sophisticated traffic control systems.

TRL also has a facility in Scotland, based in Livingston, near Edinburgh, that looks after the special needs of road transport in Scotland.

The laboratory's primary objective is to carry out commissioned research, investigations, studies and tests to the highest levels of quality, reliability and impartiality. TRL carries out its work in such a way as to ensure that customers receive results that not only meet the project specification or requirement but are also geared to rapid and effective implementation. In doing this, TRL recognises the need of the customer to be able to generate maximum value from the investment it has placed with the laboratory.

TRL covers all major aspects of road transport, and is able to offer a wide range of expertise ranging from detailed specialist analysis to complex multi-disciplinary programmes and from basic research to advanced consultancy.

TRL with its breadth of expertise and facilities can provide customers with a research and consultancy capability matched to the complex problems arising across the whole transport field. Areas such as safety, congestion, environment and the infrastructure require a multi-disciplinary approach and TRL is ideally structured to deliver effective solutions.

TRL prides itself on its record for delivering projects that meet customers' quality, delivery and cost targets. The laboratory has, however, instigated a programme of continuous improvement and continually reviews customers satisfaction to ensure that its performance stays in line with the increasing expectations of its customers.

TRL operates a quality management system which is certified as complying with BS EN 9001.

Transport Research Foundation Group of **Companies**
Transport Research Foundation (a company limited by guarantee) trading as Transport Research Laboratory. Registered in England, Number 3011746. TRL Limited Registered in England, Number 3142272
Registered Office: Old Wokingham Road, Crowthome, Berkshire. RG45 6AU

INTELLIGENT TRANSPORT SYSTEM (ITS) ARCHITECTURE

PROCEEDINGS OF A TRL INTERNATIONAL WORKSHOP
8-9 MAY 1996

CONTENTS

INTELLIGENT TRANSPORT SYSTEM (ITS) ARCHITECTURE

PROCEEDINGS OF A TRL INTERNATIONAL WORKSHOP
8-9 MAY 1996

INTRODUCTION

The idea for this Trans-Atlantic workshop on System Architecture for Intelligent Transport Systems (ITS) was born at the second World Congress on Intelligent Transport Systems, November 199.5. In my discussions with those closely involved with the USA National ITS Architecture project it became apparent that the team working for the US DOT had produced results which would have much wider significance than for the USA alone. In effect, they had been researching the framework for the integrated management of road transport infrastructure by harnessing the full potential of Computers, Information and Telecommunications. In Europe the term "Advanced Transport Telematics" (ATT) is used to describe these technologies.

In this two day workshop, coming towards the end of the US DOT's three-year project, we were able to hear first-hand from members of the ITS Architecture development team the main conclusions emerging from this study. The audience was drawn from 9 European countries, giving the opportunity for a full discussion of the American approach compared with European work on ATT system architecture. Very broadly, the US approach can be characterised as "top down", whereas until now Europe has taken more of a "'bottom-up" approach.

The workshop sessions were held in a relaxed atmosphere which encouraged a full exchange of views between the participants. I would like to record my appreciation of the contributions made by everyone who attended, but special thanks must go to those who travelled across the Atlantic to join us. We greatly benefited by having them join us in force, sharing their enthusiasm for their subject.

The workshop would not have taken place without the full support of Christine Johnson of the US DOT Joint ITS Program Office and of Susan Harvey and John Miles of ITS Focus (UK) who put together the workshop programme. The administration of the workshop on behalf of TRL fell to Jenny Eaglen of the TRL Press Office.

By publishing the proceedings of the workshop TRL hope-s the papers will stimulate further debate about the future development of intelligent transport systems into the 21st century.

John Wootton
(Chief Executive, Transport Research Laboratory)

List of Acronyms

AA	Automobile Association
AFC	Automatic Fee Collection
A-IT	Advanced Transport Telematics
CEN	Comite Europeen de Normalisation (European Committee for Standardisation)
CONVERGE	Project co-ordinating systems architecture work in the EU Fourth R&D Framework Programme (1996- 1998)
CSP	Communications Service Provider
CVISN	US DOT project on ITS for commercial, vehicles
DACCORD	Development and Application of Co-ordinated Control of Corridors (EU Fourth R&D Framework Programme)
DRIVE	Dedicated Road Infrastucture for Vehicle Safety in Europe (EU Research and Development Programme completed 1994)
DSRC	Dedicated Short Range Communication
ECU	European Currency Unit (1 ECU - $1.30 US; L0.8 14 Sterling)
ETSI	European Telecommunications Standards Institute
EU	European Union
GPS	Global Positioning System
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
HAZMAT	Hazardous Materials
HMI(MM1)	Human (Man) Machine Interface
IS0	International Standards Organisation
ISP	Independent Service Provider
ITS	Intelligent Transport Systems
MCP	Message Control Protocol
NTCI	National Transportation Communications / ITS Protocol (USA)
PAS	Public Authorities
PFI	Private Finance Initiative
RAC	Royal Automobile Club
RDS-TMC	Radio Data System - Traffic Message Channel
RTTT	Road Traffic and Transport Telematics
SATIN	Task force on system architecture in DRIVE
SOCRATES	System of Cellular Radio for Traffic Efficiency and Safety
SRD	Standard Requirements Document
TELTEN	Telematics for the Trans-European Network (EU Project)
TRL	Transport Research Laboratory
T-TAP	Transport Telematics Applications Programme (EU Research & Development Programme 1995 - 1998)
US DOT	United States Department of Transportation
UTC	Urban Traffic Control
VERTIS	Vehicle Road and Traffic Intelligence Society (Japan)
VMS	Variable Message Sign

OVERVIEW OF THE WORKSHOP: a North American perspective

Dr Kan Chen (Chairman, ITS Architecture Technical Review Team, USA)

In spite of all the discussions and work on ITS architecture that have taken place in the past three years on both sides of the Atlantic, there remains the lingering question of whether an architecture is needed. This question was raised among a number of the experts within the Technical Review Team of the USA ITS Architecture Program at the beginning of the Programme.

The alternatives to having a national architecture appeared to be (1) letting the market forces sort things out and determine the pattern of ITS deployment and/or (2) working on the ITS standards without an architecture. It turned out that the prior development of an architecture and the reliance on market forces do not need to be at opposite ends of a spectrum. The U.S. architecture has been developed with the anticipation of market forces and, in fact, with the intent to facilitate and enable the working of market forces. Similarly, the architecture has been developed to provide a framework of ITS standards development so that the various ITS standards to be developed would be compatible with one another. With the architectural framework serving as a reference, the ITS standards will be developed in a broader scope and context than if isolated standards are developed separately, thus gaining more standards stability that would encourage industrial investment in product development.

Nominally the USA has taken a top-down approach, and Europe has taken a bottom-up approach, to ITS architecture development. In fact, however, there are more similarities than differences between the two sides. Therefore there are plenty of opportunities for mutual learning in ITS architecture. As the USA ITS Program moves toward deployment, the diversity of local preferences and existing systems must be taken into consideration. The various mechanisms which the Europeans have used to harmonize their existing ITS applications would provide rich lessons to be learned by the USA. Similarly, as suggested by several European speakers, it behoves Europe to consider copying and adapting the US architecture to European needs so that the substantial investment and efforts already made by the US in its ITS architecture development does not need to be duplicated.

I would like to suggest two specific directions for immediate exploration. First, we should share success stories in ITS architecture and standards development. For example, the mechanism for architecture harmonization presented by Professor Vito Mauro at this Workshop should be studied by the US experts involved in the local deployment of ITS architecture. The CEN TC 278 standards and pre-standards already established for various ITS applications should be considered by the US experts at least as a point of departure as they commence their ITS standards development work. On the USA side, the way NTCIP standards and protocols have been established and the way the national architecture has been developed jointly with the lower-level architectures (e.g. CVISN for commercial vehicle operations) would provide lessons to be learned by Europe.

The other direction I would like to suggest is for cooperative ITS architecture development between Europe and USA. The US National Architecture is not perfect and is expected to continue to evolve in the future. New user services are being added for accommodation by the architecture. There is room for improvement even in its basic structure; e.g., making it more object oriented. Therefore, instead of direct copying or adapting the USA architecture, the Europeans might wish to consider a joint effort with their USA counterparts in future architecture development.

OVERVIEW OF THE WORKSHOP: a European Perspective

Mr Job Klijnhout (Rijkswaterstaat, Netherlands)

This workshop has shown that the USA is well placed to move quickly from ITS architecture development to full-scale deployment. Europe, too, is discussing implementation, but a major task for EU countries is to sort out the organisation of ITS and the integration of 'sub-systems' into an overall architecture.

With hindsight we can see that past attempts at explaining the idea of an architecture have often failed. There is still a need for a basic set of architecture descriptions starting at a sufficiently general level, making it clear that system architecture is not the same as a specific system design. Many European stakeholders are in the process of improving their existing systems - perhaps to expand it by including just one related service. In contrast, architecture is sold as the solution to integrating a whole series of services. The two perspectives are too far apart. Perhaps some less ambitious short-term target for system architecture would help bridge this gap.

Too little is said about how current systems can migrate towards greater integration as represented by the ITS architecture. Europe already has a significant investment in operational ATT systems. The key to integration will be to include a minimum commonalty between the subsystems, like a data dictionary, location referencing system and message formats. Policy decision tools, like the one being developed by CONVERGE, should be used to help local and regional authorities assess the benefits of greater or less integration and a common architecture.

Europe can benefit by taking on board many of the results from the US architecture work. For example, the tiered approach to ITS standards is useful: e.g. national standards for toll collection systems, regional standards for co-operation between traffic and transit centres and product based standards, like interchangeable detector units.

Finally, certain subjects, like the work of the USA Oak Ridge laboratory to find solutions to relate grid referencing information with node and link-vector route information are of such importance and of such a general nature that they should be done internationally.

I. ITS System Architecture - the US Approach

Mr Ron Heft **(U.S. Jet Propulsion Laboratory)**

The US National ITS Architecture has been developed on behalf of the US Department of Transportation (US DOT) over the past three years, very much as a public/private initiative. The project was requested by ITS America, funded and facilitated by the US DOT and agreed through extensive outreach and consensus building with key stakeholders in both public and private sectors. The objective in seeking a National ITS Architecture was to promote national compatibility in the development of ITS, thereby accelerating the ITS market and ensuring that funds are wisely spent.

The three year project adopted a “top down” approach but it also sought to be a user-driven process by ensuring full participation by key stakeholders in the architecture development along the way. The US DOT specified a set of 29 user services as the basic building blocks. The aim was to produce an architecture that was technically sound and has the consensus support of builder, buyers, and users alike. Users of ITS in this context means travellers, transportation management authorities, transit vehicle operators, commercial vehicle owners and operators, state and local governments.

One of the main products has been a national agreement on the framework for implementing ITS, which can deliver national compatibility of services (see Figures 1 and 2), secure a national market for ITS equipment and services and provide the basis for standard-setting. Major outputs are a full and complete definition of the architecture, a comprehensive evaluation of its performance and an implementation strategy that is supported by a close specification of the standards requirements.

2. US National ITS Architecture Development

Mr Richard Barber (Rockwell International Corporation)
Dr Rob Jaffe (Lockheed Martin Systems - formerly Loral Federal Systems)

Richard Barber: Overview

The US National ITS Architecture defines a framework within which the 29 core ITS services can be developed over a 15-20 year time span. These user services have been bundled into six groups:

- Travel and traffic management
- Commercial vehicle operations
- Emegency management
- Public transportation management
- Electronic payment
- Advance vehicle control and safety systems

Figures 3 to 7 show the functions supported by some of the user service bundles. Based-on a detailed analysis of how the user services might be integrated the Architecture team developed a theory of operations and a logical architecture to show the processes and interconnections that are at the heart of ITS The physical architecture that was developed out of this logical analysis shows 19 sub-systems grouped into 4 major groups, as follows:

Traveller sub-systems

Personal Information access	Remote traveller support

Centre sub-systems

Traffic management	Emergency management
Emissions management	Commercial vehicle administration
Transportation Planning	Transit management
Information service provider	Toll administration
Freight and fleet management	

Roadside Subsystems

Roadway	Toll collection
Parking	Commercial vehicle inspection

Vehicle subsystems

Personal vehicle	Transit vehicle
Commercial vehicle	Emergency vehicle

The interconnection of these systems is shown at the highest level of aggregation in the Architecture interconnect diagram (see Figure 9) which shows four main types of communications requirement: wide area wireless interfaces, wire line interfaces, dedicated short-range communications; and vehicle to vehicle wireless interfaces. These communications media overlap to some extent to give flexibility in implementation.

Within each group and for every ITS service function the architecture allows flexibility over the choice of communications medium, taking account of price, performance, geographical coverage and inter-operability requirements. Communication with the vehicle is very central to ITS (see Figure 10) .The associated equipment costs could add significantly to the cost of the vehicle and a range of price/performance characteristics can be expected.

The modular approach to the architecture, incorporating the idea of an independent service provider, is very flexible. It prescribes the system design in only the most general of terms. It does not set transport policy or require mandatory participation in ITS. However it does offer a framework within which a complex set of services can be developed. Integration and inter-communication are the pathways to securing ITS benefits, which leads to a consideration of inter-operability standards for data communications and other ITS equipment. Standards requirements are therefore an important product of the US architecture development work and are discussed further under Section 8 below.

Dr Rob Jaffe: Operational aspects

In the deregulated environment in the USA there are many Communications Service Providers (CSPs) who will provide fixed wire and wireless networks, mobile cellular and satellite-based services. Interconnections between these CSPs is developing as part of the National Information Infrastructure. The picture is one of rapid evolution towards low cost, high function shared services, which may link with or work in parallel with the Internet. The architecture is neutral about the choice of communications options, although ITS communications performance requirements are explicit in the process specifications, data loading analysis and communications architecture. Specific choices will have to be made as part of any given ITS system design, and different communications options will be appropriate for different circumstances.

Many ITS services need to communicate data and facts between sub-systems cross-referenced with locational referencing codes. A development project is now under way at the US Oak Ridge National Laboratory to develop message protocols which can efficiently cross refer geographical co-ordinates to other locational codes based on nodes, links and other network attributes,

The underlying philosophy of the ITS Architecture is to let the market decide on the form of the ITS services. Implementation will be characterised by progressive integration of current traffic management with demand management, development of dynamic route selection and guidance, transit management, etc. Independent Service Providers (ISPs) can deliver information services and other market packages to end users in a variety of ways according to customer preferences. An example might be the ISP policy on user privacy, especially when subscriber's vehicles serve as floating car traffic probes. Flexibility in ITS delivery will be the key, and the architecture provides for that.

3. Architecture Deployment Strategies

Dr John Miles (ITS Focus)

The US National ITS Architecture project has a 15-20 year forward time horizon and shows the long-term potential for developing ITS with a high degree of interconnectivity. The challenge now is to find strategies that can help move us from our current state of patchy deployment towards a more complete realisation of ITS. (See Figure 8).

Key questions are:

- How to foster the development of advanced ITS infrastructure?
- How to fund the investment - including full use of private sector sources?
- How to increase competition and reduce regulation over the ITS infrastructure?
- How to secure an open market in ITS equipment and services?

It seems likely that the creation of working partnerships between the public and private sectors will be an important part of any successful deployment strategy. There are various reasons for this, the most obvious being the need for large financial investment into ITS equipment and services which public sector budgets may not be able to cover. But ITS tends to blur the distinction between the public and private sectors in other ways. Many ITS services will depend on access to state-owned or controlled infrastructure and will need the close co-operation or active involvement of public authorities, especially the highway operators and the traffic police.

For the private sector, key factors which will build confidence for investment are a stable regulatory policy for ITS-based services, a well defined potential market sector, and the confidence to invest in technology-based products with some prospect of sustaining a competitive advantage. System architecture has a major contribution to make on this last front - the technical requirements - and may be significant in helping to determine an appropriate regulatory framework, and market product structure. For example the US ITS Architecture defines key market packages and introduces the concept of the Independent ITS service provider (ISP). Both ideas are extremely helpful in progressing our understanding of how the ITS market might develop.

Because it offers a general framework for the deployment of ITS, system architecture maintains options and avoids any firm choices. At some stage when moving from architectural concepts into system design there will have to be some technical choices made. But the existence of the architecture provides a reference framework which can underpin the basis for rational choices. In some cases this will be through standardised interfaces, in other cases it will be through industry products and proprietary (non-standard) interfaces. Thus deployment options need not be constrained by the architecture: rather the architecture informs deployment decisions.

4. European Architecture: Inter-urban Environment

Dr Jan Blonk, (TNO Netherlands)

Between 1991 and 1995, the GERDTEN project in the DRIVE programme was engaged in developing the theory and an architecture prototype for inter-urban applications of Advanced Transport Telematics (ATT). Through this work progress was made on architecture definitions, a development framework and an architecture methodology.

The following working definition of system architecture was adopted for this purpose.

> "' A system architecture is a conceptual description of a complex, distributed system, as a stable basis for the evolutionary deployment of the system"

Thus the main purpose of a system architecture is three-fold:

- To provide the sound basis for decisions concerning the development of ATT infrastructure;
- To enable sound choices to be made on the options for the main building blocks.
- To guide migration from current to future systems.

The GERDIEN project sought to develop a user-oriented approach to the architecture framework (see Figures 11 and 12) so as to address the Why? What? and How? of ATT deployment:

Why?	The architecture reference model
What?	The functional architecture and information architecture
How?	The physical architecture and communications architecture.

Rough1 y corresponding to these three architecture levels are three levels of user requirements: at the policy level a contribution to policy goals (Why are we doing this?) ; at the design level an understanding of the impact of ATT functions to be implemented (What are we implementing?); and at the operational level an aid to ease of operation and maintenance (How are we implementing this?).

The GERDIEN project successfully applied these architecture concepts to the EuroDelta test site in support of new regional traffic management and traveller information services (Figure 13). This demonstrated the value of the system architecture in steering the pilot project by indicating (1) the need for an open and flexible roadside communication system; (2) a requirement for standardised data communications between the traffic control centre and information provider; (3) a geographical data base for traffic control and information data; (4) new algorithms for travel time and flow/capacity estimates, plus short-term forecasting models.

These results are now being developed within the new project "DACCORD" (the Development and Application of Co-ordinated control of CORiDors. See Figure 14).

5. European Architecture: Urban Environment

Professor Vito Macro (Politecnico di Torino and MIZAR Atomazione S.p.A.. Italy)

Within the DRIVE programme a number of multiple city projects (notably QUARTET, SCOPE, LLAMD, and CITIES) were concerned with the closer integration of urban ATT systems. These pilot studies show that the benefits of system integration is heavily dependent on the approach that is taken. Some pilots have reported examples of high efficiency gains such as a 25% saving in journey times, 1870 reduction in emissions and fuel consumption, etc. It is believed that system integration can offer a further 50 percent on these improvements.

The design of the functional architecture and the algorithms used are critical to the success of ATT integration at the operational level. In a real market situation system integration requires system component compatibility, with suitable interfaces to allow a modular system development. The current reality is one of high market fragmentation, many local solutions and decision-makers with different individual goals.

As cities move towards wider deployment of ATT and greater integration of systems, inevitably they will have to build on previous individual (and possibly unique) choices. If system integration is to become an attractive option, the process of achieving that integration must deliver added value to the existing systems and - crucially - must avoid creating additional problems during the remaining life of those systems. From a market perspective, local authorities will have a primary role as the customers and sponsors of the Integrated Road Transport Environment. They will be involved in judging the added value of integration. Without clear benefits there will be no long-term market for highly integrated ATT systems.

A four-stage model for system integration is proposed (see Figures 15 to 20). Stage 1 represents the current situation with one-to-one links between local systems. Stage 2 requires agreement on a common data model and common communications protocols. This will permit the use of a common service network to replace the one-to-one connections. With these features in place, it is possible to move to Stage 3 and introduce some common supervisory functions between systems such as environmental monitoring with traveller information systems, transit priority and traffic signal control. The later stages (4a, 4b) of integration depend on standardised treatment of the data model at the interface between the local systems and the service network. The most advanced examples of system integration will rely on shared communications networks and a functionally distributed system architecture.

In the new project, CONVERGE, a priority will be the development of a simulation tool to assess the impact of different architectures. It is hoped to test and make this analysis tool available in 1996.

The main conclusion of the research to date is that standardised data models and system interfaces are required at both the conurbation and local levels of system integration (levels 6 and 4 as described by the SATIN task force.)

6. Harmonisation of European System Architecture R & D results

Dr Peter Jesty (University of Leeds) and Mr Ian Leighton (W.S. Atkins)

System architecture provides a stable basis for a working and workable system [see Figures 21 to 24). The architecture should not be prescriptive of the system design - this seems to be a common misconception - but will be a description of a class of systems and a set of designs. System architecture can specify structures which are stable and fixed and system features which may be found many times.

Under the EU Fourth Framework programme the CONVERGE project provides the horizontal co-ordination of system architecture development across all projects in the Transport Telematics Applications Programme (T-TAP). This work builds on the results of the SATIN Task Force in DRIVE I and II. In the European context a decentralised approach is necessary to fulfil local requirements and modify the architecture in response to local legal and political issues. At the same time, central co-ordination can identify common opportunities for system integration and act as a stimulus for the European market in ATT.

The CONVERGE project is co-operating with the T-TAP demonstrations and validations by promoting the use of system architecture concepts and by providing the guidelines and tools for project developers. Individual projects will be expected to evaluate their systems against eight different dimensions:

Performance	Useability
Flexibility	Maintainability
Safety & reliability	Cost effectiveness
Security	Manageability

CONVERGE will identify good practice and common requirements amongst the projects and work to form a consensus around the European requirements for ATT system architecture.

7. Architecture concepts for the Trans-European Road Network

Mr David Bowerman (ERTICO: ITS Europe, Belgium)

Early deployment of a basic framework for ATT systems has been identified as a priority for the Trans-European Road Network. The motivation comes in part from the need to develop basic traffic management and driver information services but also a wish to develop the European market for in-vehicle equipment, estimated at 18 billion ECU ($23 billion) over the next 10 years. Through the TELTEN projects (Telematics for the Trans-European Road Network) a start has been made on developing a framework within which traffic management and information systems can be developed.

TELTEN1 (1993/94) covered logical architecture, systems architecture and organisational requirements. The current project, TELTEN2, is developing a planning framework for traffic management and road user information services at national, Euro-regional and pan-European levels. The main backbone of services will include improved traffic monitoring, new organisational structures, and the basic principles for trans-national data exchange.

Financing arrangements - currently up to 16 million ECU for roads ($20.5 million) will be made available under the TEN-Transport budget line of the European Union, to cover co-financing arrangements, loan guarantees and interest rate subsidies. EU funding will supplement public finance at the national/regional level and private financing of ATT based user services, in response to market opportunities.

The TELTEN functional specification is aimed at developing the basic building blocks for the ATT architecture, for example agreed formats for the data items flowing between the parties, identification of appropriate communications links, and the organisational needs. Results will be refined at three levels: national, Euro-regional and pan-European. Already there is a strong commitment to an RDS-TMC service across Europe. The new High Level Group on Road Transport Telematics is expected to develop the policy framework for implementing ATT.

8. U.S. Standards requirements and Interfaces

Dr Russ Taylor (Lockheed Martin Systems)

A main product of the US DOT programme on ITS architecture is a standards development plan supported by the Standards Requirement Document (SRD). The purpose of standards is to foster the adoption of ITS and reduce the risks to individual equipment developers.

The SRD provides a staging point for a number of Standards Development Organisations in the USA who have begun work on the interconnection and interoperabiliby requirements of ITS. It provides an overall context for the work, maintains the integrity of the architecture and allows near-term efforts to keep sight of long-term needs.

The SRD draws from the architecture reference model and all the equipment packages. At the heart is the ITS data dictionary consisting of 2500 elements for the 29 user services. To identify priorities, all the physical interfaces in the architecture were assessed for their importance for standard-setting efforts based on the leverage that can be achieved from an early standard, the maturity of the technology being considered, the importance of the interface to ITS users, and other stakeholder priorities, drawing on results of a system architecture workshop held last year.

Other factors influencing the standard-setting priorities for ITS interconnections were the status of existing standardisation efforts and the degree to which international cross-border linkages are required. A four stage rating was made of the level of inter-operability required:

1. National level standards, directly required for national inter-operability (eg DSRC for nationwide communications with moving vehicles)
2. Regional level standards not directly required for national inter-operability but necessary for regional areas (eg for direct connections between local agencies), and may expand towards national inter-operability.
3. Product level standards, not required for national inter-operability but needed to achieve economies of scale, eg for interfaces primarily within one agency.
4. None: either private proprietary communications or a physical interface will be adequate.

Figures 3 to 7 show some of the National, Regional and Product level standards for the USA International standards were not explicitly identified but the candidates include:

Dedicated Short Range Communications (DSRC), for tolling, border clearance and in-vehicle signage
Vehicle-to-roadside and vehicle-to-vehicle communications for advanced vehicle safety and automatic highway applications.

Arising from this work, a set of eleven priority standards requirements packages were proposed for early development activity. They are:

Dedicated Short Range Communications (DSRC)
Digital map data exchange and location referencing

Information Service Provider wireless interfaces
Inter-ccntre data exchange for commercial vehicle operations
Personal and hazardous materials "Maydays"
Traffic management sub-system to other centres (except Emissions Management and Independent Service Provider)
Traffic Management Subsystems to roadway devices and emissions sensing & management
Signal priority for transit and emergency vehicles
Emergency management to other centres (except Emissions Management)
Transit management to transit vehicle

9. ITS Architecture Standards

Mr Bob Williams (The Enterprise Consultancy, UK}

"You will always have an architecture [by default] . . . but will you know what it is?"

A system architecture will characterise the framework and relationships in a system and will enable a coherent, consistent and inter-operable design of systems. But it is quite distinct from system design and system implementation, It is primarily about information and its management, not the physical hardware. The architecture for ITS must therefore be designed to promote the exchange of information.

The main work to set international standards for ITS architecture is taking place within Working Group 1 of ISO Technical Committee 204(ISO TC 204). Under a standing agreement between CEN and ISO, the ISO Working Group takes the lead and the equivalent CEN Working Group (CEN TC 278 WG 13) shadows it, with responsibility for co-ordinating a European perspective on Road Traffic and Transport Telematics (RTTT) architecture. The main areas of activity currently are the development of standards for architecture taxonomy and terminology.

A first draft high-level architecture was circulated for consultation in December 1995. A glossary of terms was issued in November 1995 and work on the first issue of the data dictionary and taxonomy is well under way. The ISO reference architecture has been reconciled with the ITS architecture (USA), SATIN Task Force proposals (EU) and VERTIS (Japan). The objective is to produce open standards that are enabling and not prescriptive. The approach taken is object oriented, relating to the key actors, relationships and common characteristics. It recognises 32 fundamental user services linked to a basic set of common functions.

A consideration of the architecture will be needed in all the standards working groups of IS0 TC 204 and CENTC 278. The architecture Working Group will recommend procedures but the level of detail will be left to the other groups. Once the development and integration of comments in response to the current draft is complete, ISO TC 204 WGl will issue a second discussion document and ask other working groups to consider the work, criticise, develop and modify it. This will be demanding of time and resources, and requires an input from all nations and international programmes with an interest. Those who do not participate may be too late. Individuals from ITS Focus, UK DOT and ERTICO are encouraged to get involved.

10. Architecture, standards and the SOCRATES approach

Mr Ian Catling (Co-ordinator for the SOCRATES consortium)

The SOCRATES consortium has been developing the architecture for ITS services since 1989, beginning with basic research, followed by field trials to test the SOCRATES system architecture (see Figures 25 and 26) and now moving into full-scale implementation. SOCRATES is developing a set of ITS applications using GSM digital cellular mobile telephone communications.

SOCRATES applications include dynamic route guidance, emergency services, driver information, fleet management and traveller information. Key mobile interfaces will use the GSM packet data services (GPRS). The message control system needs to allow for point data and geographical data and transmission protocols for the applications. These will shortly be offered as a pre-standard through CEN TC 278 WG4. Links between SOCRATES information centres will enable trans-European data exchange, including payment clearance arrangements. Connections with traffic and travel information centres will also be part of the architecture.

A memorandum of understanding between the German companies actively developing SOCRATES is in preparation to provide a common basis for Irtra-GSM services, whilst at the same time allowing competing products to develop. There will be a need for standards for the communications based on GSM, location referencing based on GPS and support for the Human-Machine Interface, etc. To a large extent these can be proprietary interfaces and product standards, but some input from the standards-setting bodies (eg ETSI) will be needed for the intra-GSM aspects of the SOCRATES service.

In summary, SOCRATES will use standards and proprietary interfaces for different levels:

Base technologies	GSM digital cellular telephony and GPS (Global Positioning)
Message level:	GPRS (GSM digital packet data service), MCP (Message Control Protocol), Intra-GSM (linkages between GSM operators)
Application level	ADP (Message Application Protocol), AFC (Automatic Fee Collection protocol) and HMI (Human Machine Interface)
Operator interface:	data presentation, information structure, operator procedures.

REPORTS FROM THE SYNDICATE GROUPS - DAY 1

Day 1. Syndicate **1.**
Is a Federal/European/National System Architecture Necessary?

Chairman - Dr William Gillan - Department of Transport
Rapporteur - Mr Robert Cone - Welsh Office

Introduction

The existence of an architecture is implicit in any system. The question is whether it is understood and documented. An architecture will only work efficiently if the standards associated with it are enabling, not proscriptive. One important role of an architecture is to help people from different disciplines communicate without misunderstanding. A systems architecture needs to be all embracing.

Defining an architecture will achieve:

- Development of services and availability of information for use and exchange between systems and the development of payment mechanisms. For example, in the UK Trafficmaster have invested heavily in data collection equipment. They would not release this information into the public domain without some mechanism for obtaining revenue.
- Encouragement for new entrants to the business and the fostering of competition. Even existing players have difficulty knowing which products to develop. A framework provides evidence of stability and guidance about future market places.
- More efficient use of resource by sharing data and information, and avoidance of duplication. For example census equipment could also be used for providing real time information.
- More efficient use of resource by avoiding duplicated development.
- Easier integration of equipment from differing sources.

Who is responsible for creating (or documenting) an architecture? Will it happen by itself?

Responsibility for defining architecture should lie with standardisation organisations who operate in the public domain and make use of the knowledge of experts in the field.

Even without intervention a defacto architecture will emerge. Once established it will encourage high market penetration and further development of the product. The price will be driven down (e.g. IBM PC). Intervention to establish an architecture will accelerate the process of developing markets and products. This is the approach being taken in the USA.

Implementation of an architecture is voluntary. Implementors will continue to implement an architecture if it is good. Within Europe it is possible to enforce the application of an architecture and standards for public procurement. It is policy that where a CEN standard exists this is taken into account.

Does an architecture demand Intervention in competitive markets?

An architecture must not limit a design. Technology changes fast and an architecture cannot anticipate technological development. It must be independent of the medium employed. A good example of a lasting architecture is the IS0 layer model which is still valid after 20 years, because it is completely technology neutral.

An architecture should facilitate not hinder competition. Industry needs a stable framework in order to minimise the risk associated with investing in the development of products and systems. Customers will not purchase goods freely unless they understand the usefulness and life of products. An architecture provides the stability and understanding that both consumers and suppliers require.

A clear architecture will reduce the cost associated with entry to a market and reduce development thus increasing competition and volume and, hopefully, drive down unit costs.

Should a systems architecture be National, Federal (pan-European), or International?

Development of products in this field is embryonic. The size of the market for products and services will vary according to the product. Whilst some products will develop within national boundaries the real economies of scale can only be obtained by selling to the entire market, whether U.S. or European. Clearly a global market offers most potential.

At the international level IS0 and CEN are working together in the field of traveller information. Within Europe it is policy that standardisation will take place at the European level not the National level. However, it is notoriously difficult to get agreement from all European countries.

There is no reason why National versions of a system architecture should not co-exist within a greater European systems architecture.

Conclusion

Many would benefit from a clearly understood architecture/framework for ITS. It would help the authorities and road operators specify and procure infrastructures, the private sector to finance and develop products, services and equipment and the users to make investment decisions. The community benefits from competition, economies of scale, ease of use and reduced duplication of work and development effort.

A common Federal or pan-European architecture is better still but may be difficult to achieve.

Day 1. Syndicate 2.
ITS Benefits, Synergy and Risks

Chairman - Mr David Clowes - W.S. Atkins
Rapporteur - Dr Alan Stevens - TRL

It can be difficult to distinguish between the benefits/synergy/risks of having an ITS architecture and the benefits/synergy/risks of the individual or combined ITS functions. However, the following points in the discussion concentrated on the concept of architecture (although the point was made that we still may have different perceptions of what an architecture actually is!).

Benefits

An architecture provides the basis for the development of standards. Flowing from standards come benefits in terms of creating an open market (competition, price reduction etc) and greater confidence in the stability of the market.

ITS is different from historical approaches to transportation and requires multiple actors to interact. Architectures allow communication between the different actors to take place.

An architecture potentially provides larger markets and "lowers the threshold" for entry by providers of systems and services. For example, if roadside infrastructure is installed (in order to deploy certain ITS functions in a coherent way according to the architecture) then other functions become economic or possible and new suppliers can join in.

The existence of common architectural approaches facilitate the comparison and sharing of experiences between separate "islands of implementation".

Synergy

By highlighting synergy, development costs are reduced and combined systems provide benefits which are greater than the individual systems or functions acting alone. Indeed, functions may become possible or economic that were not previously.

Architectures highlight opportunities to integrate ITS functions and to develop key technologies that are common to different functions.

Because of the size and complexity of many systems, an architecture allows partial implementation (for example, by Local Authorities) in the knowledge that additional functions can be added incrementally as further funds or requirements are identified.

Risks

The main risks of trying **to** define an overall architecture for ITS were identified as follows:

- getting it wrong technically (such that no one follows it)
- not sufficiently meeting the needs of users
- being too prescriptive or not being prescriptive enough
- being too late (or too early)
- not encompassing existing systems
- placing an unwarranted burden on new implementations
- not being sufficiently "inclusive" to allow all parties to benefit

Other main points of discussion

Apart from the need to get a better common understanding of architecture and its **benefits,** three main points were raised as questions:

1. Has the ITS world paid sufficient attention to the "Enterprise model" which tackles the distribution of costs and benefits in such a way that business risk is contained and the private sector can be involved in ITS services?

2. How is the question of "ownership" to be addressed in terms of funding, championing and disseminating the concept of an overall ITS architecture?

3. How can the costs and benefits of having an overall ITS architecture be quantified?

Day 1. Syndicate 3.
ITS and the Vehicle

Chairman - Dr Phil Hunt - TRL
Rapporteur - Mr Malcolm Williams - Jaguar

Need

There is a need for the following range of ITS functions to enable the Vehicle to fulfil its role as the INTELLIGENT VEHICLE in the ROADS of the future:

- Location coding and determination
- Communications both from infrastructure to the vehicle and from the vehicle to the infrastructure.
- The information needs to be defined and coded to enable multiple languages to be efficiently communicated.
- It is expected that multiple service providers will develop to provide a wide range of services.
- Multiple systems will be developed to satisfy the needs of the USERS.
- The in-vehicle systems will need to be produced in high volume.
- The quality of the information will need to be very high to gain customer confidence.
- Barriers to implementation will **need** to be addressed and removed to enable a satisfactory service to be provided to the customer.

- Regulations promoting standards of systems and standards of service require consideration.
- Public awareness of the benefits to both society and the individual user needs to be promoted.
- Social pressure will be a force in developing the features and benefits, and in the selection of systems which will be successful.

Architecture

All the above is necessary to enable the VEHICLE to play its role in ITS SYSTEMS being proposed/developed today.

An architecture is required to enable system providers to confidently develop their components and services. Standards are also required, and an architecture assists in the development of standards by providing a reference for the working groups to use.

European Position

Europe is well placed in the development of services and systems. RDS-TMC and the GSM cellular communication network are examples of ITS systems which are highly developed.

The Mayday message system was proposed as a product which would be an early success.

Day 1. Syndicate 4.
Integrating Traffic Management and Information Centres

Chairman - Mr Mike Talbot - DOT
Rapporteur - Mr Ken Oastler - London Traffic Control Systems Unit

There is a distinction to be made between general information which can be provided from public funds and personal data which should be paid for by the individuals who directly benefit. In the USA the public authorities' fear of litigation and their reluctance to extend their liability to litigation by providing personalised information services has influenced the National ITS architecture towards separate centres for information and traffic management.

It was agreed that some data processing by traffic managers was essential for their operations. For example to provide data concerning the use of the road network for planning, for the operation of VMS signs, for managing congestion and possibly for public broadcast radio information. The ARENA project provided, therefore, an interface from which private sector operators could take information. Since public funds are limited, this information must be produced automatically by the system, so far as possible.

How can private sector information centres be funded - who are the clients? What is the likely return on investment? At present traffic information is provided free of charge to the motorist (although it may be funded by advertisers) and motorists are known to be reluctant to pay much for added services.

The UK's motoring organisations (RAC and AA) regard the costs associated with assembling and distributing data as costs to be carried by the public sector. They also believe that the institutional structures in the UK are presently too complex and that regional public sector centres would be required.

Both the RAC and AA are looking for income streams to fund their present services. If an income stream could not provide the proposed architecture permitting such services, then market forces would determine if they were required.

Information has to be credible and interactive forecasting techniques are needed to improve the ability of information providers to predict what conditions will develop in the network.

It was considered that an overall architecture was required to give private sector firms the confidence to develop products quickly despite the slow development of public sector facilities. The architecture should not restrict the public sectors' ability to impose transport policies.

Finally, as congestion increases the need for accurate information increases, and both the public sector and individuals are likely to be more willing to pay for information.

REPORTS FROM THE SYNDICATE GROUPS - DAY 2.

Day 2. Syndicate 1.
International Standards Development Priorities

Chairman - Dr William Gillan
Rapporteur - Mr **Terry Sullivan - Highways Agency**

This syndicate session was well attended with a wide spread of interests. The topic, priorities in international standards development, prompted an effective and interesting discussion and resulted in a significant level of common understanding.

The group noted that in UK and Europe most of the new formal standardisation activity is directed towards international rather than national standards. The group first looked at how standardisation requirements are identified, and recognised two main paths;

- The "top down approach' where an overall architecture indicates where standards are required and their form and relationship with others (eg. digital map and location referencing)

- the "bottom up approach" where a standard is required to implement a single service or product (eg. Radio Data System Traffic Message Channel - RDS-TMC message).

These will also help to determine priorities but it was also recognised that priority might be given to standards that could be quickly and easily developed as ""small gains" are very useful in the early stages of establishing markets like RTTT.

From personal experience the group quickly identified the following candidates as priority areas for standardisation;

Architecture - Reference model, taxonomy, data dictionary
Toll collection - Standards to achieve interoperability
RDS - TMC
Dedicated Short Range Communications between road and vehicle (DSRC)
Digital map and location referencing

The group were then asked to write down their top three priorities for standardisation and also any barriers to the standardisation process. These were reviewed quickly to try to quantify or rank the priority. This confirmed the following which were identified by three or more as being top priority;

DSRC - also to include the wider architectural aspects
Data dictionary/data messages
Map and location referencing

A complete list of the suggestions is attached.

This exercise also usefully identified the following candidates for standardisation which prompted interesting discussion;

- Mayday Messages: The US members reported that two different systems had been implemented in the US by motor manufacturers. They felt that compatibility with other services could be achieved at the service provider level without a detailed standard for the messages from the vehicle.

- Safety: It was accepted that safety was particularly important in transport applications. It must be addressed in each service and might be considered alongside aspects like quality. It was further recognised that systems utilising large numbers of interoperating services provide additional difficulties for safety analysis. A reference model may be useful which indicates how and where the essential safety features of a service are addressed.

- Human-Machine Interface: A good in-vehicle HMI is essential both for user acceptance and safe operation. Standards in this area must allow for customised products in this very competitive commercial area.

The group also noted and discussed the following aspects regarding the standardisation process:

- Involvement: Greater involvement in the standards process was seen as the single main requirement to speed up the production of standards. This encompassed both additional input from the technical experts and also recognition and sponsorship from the Authorities who would benefit from the availability of good standards.

- Commercial Protectionism: This could be a barrier but it was also recognised that commercial advantage proprietary solutions were necessary for the private sector to play their full role in a market orientated area like RTTT.

- Timescales: The time required to prepare standards was seen as a barrier to participation.

Suggestions for priority standards

Roadside equipment shared communications network
Location referencing at the roadside level
Tolling/Fee collection
UTC data interfaces
RDS-TMC messages and location references
Data exchange between applications at the control centre level
Air Pollution Monitoring
Cellular positioning
Electronic money
International roaming for GSM

DSRC including architecture level approach
Urban to interurban communications
Safety reference model
Communications interface for information and control
MMI messages
Message sets for mobile travellers
Location referencing
Digital map data exchange
Wireless interface to vehicle for Information, Tolling & Mayday
Mayday Messages
Traffic information message sets
Reference architecture
Glossary of terms
Data dictionary
Traffic information quality
Safety of ITS applications (methods and measurements)
HMI interface

Day 2. Syndicate 2.
The need for ITS Architecture

Chairman - Mr Mike Talbot - Department of Transport
Rapporteur - Prof. Mike McDonald - Southampton University

Situation

Transport problems: inefficient, unsafe, polluting

Why ITS?

- unique new solutions
- more cost-effective solutions
- politically acceptable solutions

Problem

- ITS Implementation does not take off
- Recognized by EC already in 1993. Therefore recent setting up of High Level Group by Council of Ministers.

Why lack of implementation?

- benefits clear, but often at high, macro-economic level
- ITS often interactive (not one, but multiple, interdependant parties: risks and benefits unevenly divided)
- market predictions unclear for private parties because of undefined situations

- early phase market where large common (infrastructural) investments are required (e.g. for basic traffic information) for which no single private party likes to carry the whole burden and see only part of the benefits
- probably small, fragmented markets instead of large scale ones, if no central action is agreed.

All this increases the threshold for investment and business initiatives.

Therefore there is a need for:

ITS Architecture

- which has implementation as its purpose
- therefore is based on the real world
- accommodates existing capital investment
- realistically is based on the different interests of different parties (as large scale market, continuity and profitability for private partners)
- defines coherent clusters of functions
- identifies common infrastructure, modules and interfaces
- thereby identifies priorities for standardisation
- and allows the benefits of synergy

In the process to implementation, architecture is an essential stage for both reasons: to facilitate take off and to experience the full benefits.

In this, the single most vital aspect will be CLEAR COMMUNICATION where all people involved have to be addressed at their level of perception and be made to understand what the implications for their field of responsibility will be.

To facilitate take off: System architecture is a model to describe and clarify part of the world, meant to lead to easier, better and more efficient implementation. At high level it can describe interests and requirements of multiple parties, at a low level the term is often used for the design of a physical subsystem. Be sure it is always clear what you mean.

Day 2 Syndicate 3.
What does ITS Architecture Offer the Private Sector?

Chairman - Mr David Clowes - W.S. Atkins
Rapporteur - Mr John Cheese - Smith System Engineering

‘Buy-in’

Rockwell, heavily involved in the ITS Architecture development programme, has used the architecture to map out a strategic technology development plan internally across all Rockwell’s transportation divisions. More generally, through ITS America and during the programme not only major stakeholder groups, but also suppliers and users, have been consulted and kept informed continuously. The NTCIP standard is already becoming widely adopted by suppliers and users.

Who pays?

The European ITS market is currently seen as marginal and fragmented. There is little or no evidence of users willingness to pay for travel information. There is some apprehension amongst European manufacturers over abandoning proprietary national standards in favour of open systems.

The critical issue for open architectures is can they crack open the ITS market, moving it towards a higher value mass market? If the architecture development alone costs $30m how much will systems development cost? Is the market there to spread these costs of development? (The US perception was a resounding yes!).

Specific benefits of ITS for the private sector

There was agreement on the following points:

- reduction of risk for both purchasers/users and suppliers.
- its a commercial decision for each company about whether to get involved in and adopt the standards but those in at the start will be two years ahead of everyone else.
- Architecture defines the functionality, not the technology to be used and should therefore be relatively future proof. Manufacturers can develop relatively stable hardware platforms and upgrade functionality over time.
- Who pays? Architecture points to the direction, companies should be looking for new opportunities.
- Architecture helps development of systems and portfolios of services rather than single applications, thus providing higher value to the user.

How will investment and implementation proceed?

There was a perception that many of the opportunities that the private sector would tend to target (eg. in-vehicle systems, ATIS and other service provision opportunities) were dependant on good, comprehensive data sources (in other words ITS infrastructure) which was perceived to be a public sector responsibility. In the UK privatisation, funding mechanisms like the PFI, and other public-private partnerships blur this distinction between public infrastructure and private service provision.

It is important that the Architecture provides a clear evolutionary migration path for the development of existing ITS systems towards the full functionality the architecture defines.

Private sector investment and standards development effort in ITS will follow where the money is whether via public procurement policy, commercial market opportunities, federally funded programmes or other means. The key issue remains, where is the money in ITS?

Day 2. Syndicate 4.
What does ITS Architecture Offer the Public Sector?

Chairman - Dr Phil Hunt - TRL
Rapporteur- Mr Ken Laughlin - Hampshire CC

The question of what can an ITS architecture offer the public sector in itself raised a number of other important questions. These included: to what extent should the public sector be involved in the architecture development? What is the link between the architecture and the policy objectives - are they dependent on each other? What does the public sector want from an ITS architecture? Can the architecture resolve the organisational, institutional and financial issues that currently exist? The syndicate considered a number of these issues and the outcome of the discussions are summarised below.

There is a need for an architecture to ensure interoperability for Intelligent Transport Systems (ITS) in the future by providing a framework for the development and procurement of ITS. The development, subsequent acceptance and use of an architecture for ITS should be underpinned by the private sector but the public sector has an important role to play in ensuring that the ITS architecture does not become inflexible and can meet the various policy objectives that public authorities (PAs) will want to implement. The development of an architecture can be used to facilitate public/private partnerships to take this forward from both a technical and fiscal point of view. The partnerships will enable alternative methods of financing ITS to be explored for both the public and private sectors.

PAs have and are developing transport policies to take account of increasing traffic growth and congestion, particularly within urban areas. PAs have no choice in this matter and ITS is the way forward as the tool in the implementation of these policies. PAs will want to ensure that the ITS architecture is sufficiently flexible to implement both 'carrot and stick' techniques to enable a sustainable policy to be delivered. There are strong links between the policy and the architecture but the policy objectives should not drive the architecture; and vice versa. The ITS architecture will have to be designed in such a way as to permit PAs to adopt a modular approach to building an ITS. Not all PAs will want or need all of the facilities that are likely to be available. The ability therefore to select the appropriate tools and techniques in the knowledge that they will operate and communicate, and can be extended, is very important.

Aspects that continue to be a problem in the development of ITS are the organisational and institutional issues at the national, regional or local level. The development of an ITS architecture will help by identifying or highlighting areas where barriers exist and steps can be taken to overcome the problems that are arising. The involvement of the public sector needs to be at a high level within the ITS architecture. National Governments have a role to play acting as a catalyst in overcoming a number of these organisational and institutional issues.

Co-operation between the public and private sector during the development of the ITS architecture is seen as vital and will provide a technical framework for the private sector to deliver the systems. However, there is still a need for the public sector to be convinced of the benefits of ITS. Whilst an architecture will provide a stable base for the development of ITS it will be important that the functionality and not the architecture is used in the process of justifying expenditure to both the political members and the professional engineers within the public sector. The process that took place in the USA of involving the public sector in the development of the architecture through the OUTREACH programme was seen to be a good model as was the lead taken by the USA Government in the development of the ITS architecture.

In summary, ITS will allow a wider set of objectives to be met in dealing with the transport challenge. The public sector will require the ITS architecture to provide the framework for the development and subsequent procurement of ITS. The architecture will need to be sufficiently flexible to:

- implement policy objectives
- highlight organisational/institutiona1 issues
- provide a modular approach to ITS
- obtain cost effective systems
- enable an open market
- ensure interoperability
- enable alternative financing
- enable public/private partnerships

Annex 1

NATIONAL ITS ARCHITECTURE
A JOINT U.S./EUROPEAN WORKSHOP

Wednesday 8th & Thursday 9th May 1996
At the Cantley House Hotel, Wokingham, Berkshire, U.K

WEDNESDAY 8th MAY - ***Chairman, Dr John Miles, Director Public Policy, ITS Focus***

09.30 **Welcome and Introduction**
John Wootton, Chief Executive, TRL

09.40 **Overview of US Department of Transportation ITS Programme**
Ron Heft, US Jet Propulsion Laboratory

10.10 **US National ITS Architecture Development**
Richard Barbel; Rockwell and Rob Jaffe, Loral, USA

10.40 **COFFEE**

11.00 **US National ITS Architecture Development - continued**

11.30 **Architecture Deployment Strategies: Discussion Session**
Chair - John Miles, ITS Focus, UK

12.10 **LUNCH**

13.15 **European Architecture: Inter-urban Environment**
Jan Blank, TNO. Netherlands

13.45 **European Architecture: Urban Environment**
Vito Mauro, Mizar International, Italy

14.15 **Harmonisation of European R & D Results**
Peter Jesty, University of Leeds

14.45 **Architecture Concepts for the Trans-European Road Network**
David Bowernwn, ERTICO

15.15 **TEA**

15.30 **SYNDICATE SESSIONS - Four Syndicate Groups**

1. **Is a Federal/European/National Systems Architecture Necessary?**
2. **ITS Benefits, Synergy and Risks.**
3. **ITS and the Vehicle.**
4. **Integrating 'Traffic Management and Information Centre.**

16.30 **Sessions End - Chairmen and Rapporteurs Meetings**

17.00 - 18.00 **Reception - hosted by ITS Focus**

~~~~~~~~~~~~~~~~~~~~~~~~~~

THURSDAY 9th MAY - ***Chairman, Dr. John Miles, Director Public Policy, ITS Focus***

09.00 **PLENARY SESSION - Report back by Chairmen of Syndicate Sessions followed by open discussion**

09.40 **U.S Standards Requirements and Interfaces**
Jim Larsen, Rockwell and Russ Taylor, Loral, USA

10.40 **COFFEE**

11.00 **European Standards Requirements and Interfaces**
Ian Catling, Ian Catling Consultancy and Bob Williams, Enterprise Consultancy, UK.

12.00 **SYNDICATE SESSIONS - Four Syndicate Groups**

1. **International Standards Development Priorities.**
2. **Effective Implementation Strategies.**
3. **What Does ITS Architecture Offer The Private Sector?**
4. **What Does ITS Architecture Offer the Public Sector?**

12.45 **LUNCH**

14.00 **SYNDICATE SESSIONS RECONVENE**

15.15 **TEA**

15.40 **PLENARY SESSION**
Report back by Chairmen, followed by open discussion

16.40 **SUMMING UP - Summary by Rapporteurs**
Kan Chen, KCI and Job Klijnhout, DOT, Netherlands

17.00 **CIosing Statement**
~~~~~~~~~~~~~~~~~~~~~~~~~~

Annex 2

NATIONAL ITS ARCHITECTURE
A JOINT U.S./EUROPEAN WORKSHOP

Wednesday 8th and Thursday 9th May 1996
At the Cantley House Hotel, Wokingham, Berkshire, UK

Delegate & Speaker List

Name	Company
Mr Jacques Balme	CERTU
Mr Richard Barber	Rockwell International
Mr Eduardo Barreto	European Commission
Prof Torbjorn Biding	Swedish National Road Administration
Mr Jan Blonk	TNO
Mr Richard Bossom	Siemens Traffic Controls
Miss Ruth Bridger	AA
Mr Ian Catling	Ian Catling Consultancy
Prof Chris Cernes	Cemes Associates
Mr John Cheese	Smith System Engineering
Viscount Chelmsford	ITS Focus
Dr Kan Chen	KCI
Mr David Clowes	W S Atkins
Mr Robert Cone	Welsh Office
Mr Mike Dalgleish	Golden River Traffic
Mr Nigel Davies	RAC
Mr Richard Eastman	Highways Agency
Mr Bruce Eisenhart	Loral Federal Systems
Mr Gino Franco	MIZAR Automazione
Mr Mark Gaynor	DOT, London
Dr Bill Gillan	DOT, London
Mr Geoff Gwynne	Logica UK
Mrs Susan Harvey	ITS Focus
Mr Ron Heft	US Jet Propulsion
Dr Neil Hoose	Golden River Traffic
Dr Phil Hunt	TRL
Dr Rob Jaffe	Loral Federal Systems
Mr Peter Jesty	University of Leeds
Mr Matti Karlsson	Nokia Research Centre
Mr Steven Kemp	Traffic Director for London
Mr Job Klijnhout	DOT, Netherlands
Dr James Larson	Rockwell International
Mr Ken Laughlin	Hampshire County Council
Mr Bob Le'Burn	Defence Research Agency
Mr Alastair Light	British Telecommunications
Mr Colin Maclennan	DOT, London

Prof Vito Mauro	MIZAR Automazione
Prof Mike McDonald	University of Southampton
Mr Mike McGurrin	Mitre Tek
Dr John Miles	ITS Focus
Ms Mirja Noukka	Finnish National Road Administration
Mr Peter O'Neill	Traffic Solutions
Mr Kenneth Oastler	TCSU
Mr Bipin Radia	DOT, London
Mr Ian Routledge	Oscar Faber
Mr Raymond Starsman	ITS America
Dr Alan Stevens	TRL
Mr Terry Sullivan	Highways Agency
Mr Mike Talbot	DOT, London
Mr Russ Taylor	Loral Federal Systems
Dr Jan Tierolf	DOT, Netherlands
Dr John Walker	Racal Research
Mr Nigel Wall	British Telecommunications
Mr Bob Williams	The Enterprise Consultancy
Mr Malcolm Williams	Jaguar Cars
Dr Keith Wood	TRL
Mr John Wootton	TRL
Mr Peter Yendall	Oscar Faber

Annex 3

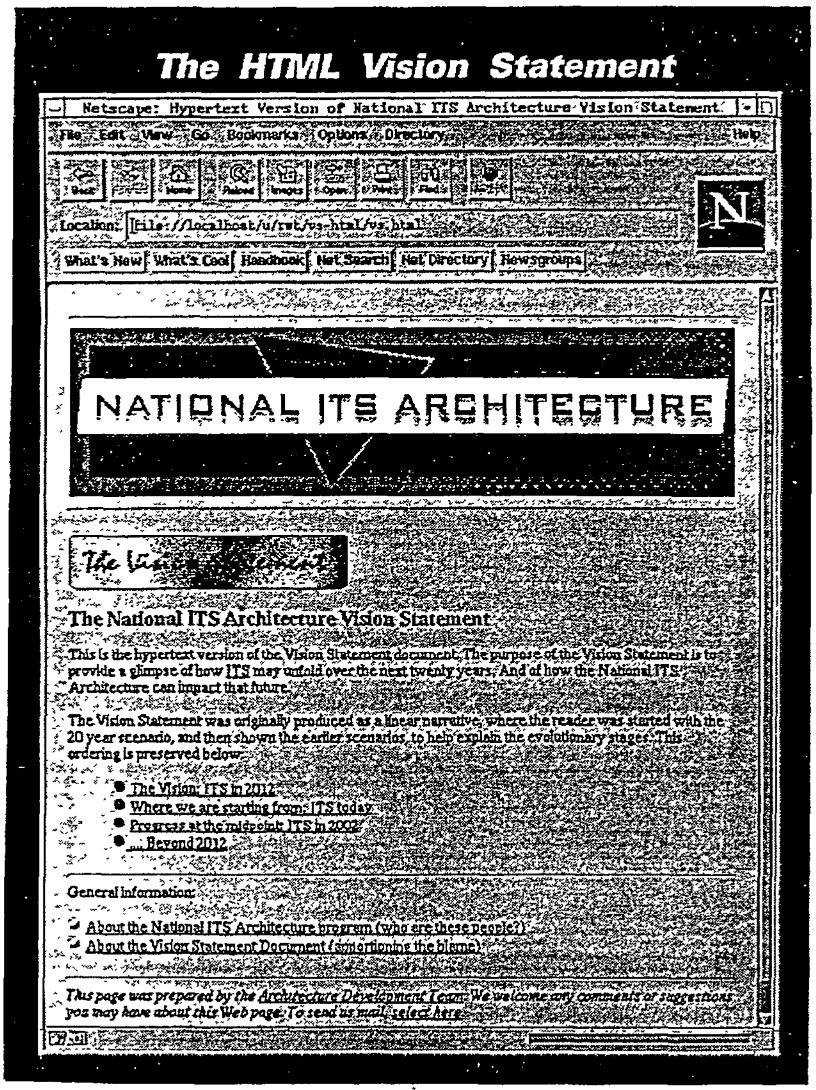
US ITS **National Architecture World Wide Web Site**
Dr Jim Larsen (Rockwell International Corporation)

A World Wide Web site has been created to access the extensive documentation that now exists on the US National ITS Architecture. It can be accessed via:

http://www.rockwell.com/itsarch

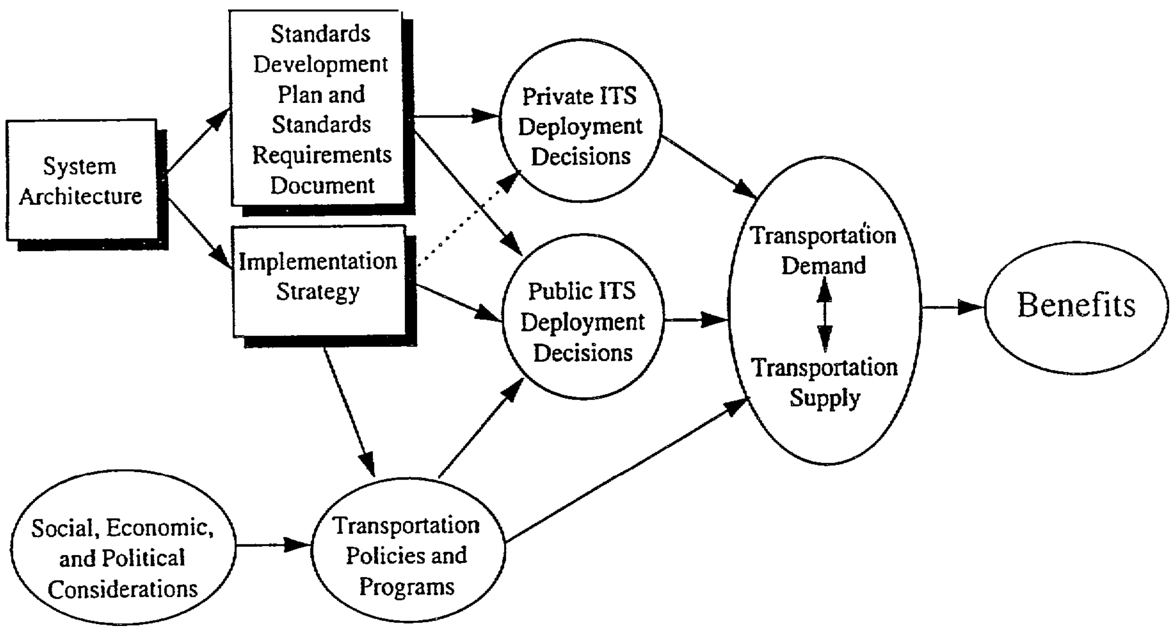
The architecture descriptions are linked together cross-referenced in hypertext. The opening screen leads to a Vision statement on ITS in the year 20 12, where we are today and expected progress at the mid-point. From the Browsing site it is possible to access the Subsystems and terminators for the architecture, details of planned ITS deployments, standards requirements packages, process specifications and data flows. The catalogue for standards developed by the Jet Propulsion Laboratory for ITS America is available on:

http://www.itsa.org/standcat/viewlist.html



Architecture
Development
Team

Benefits Framework

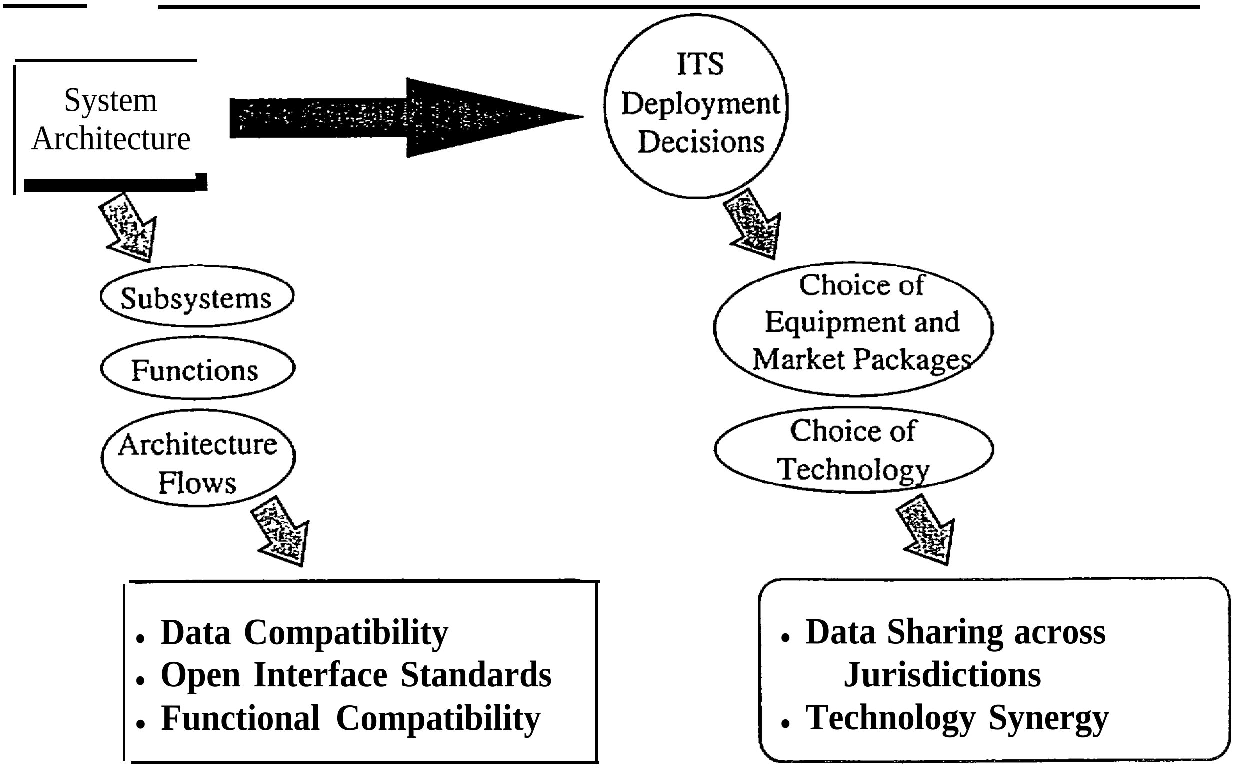


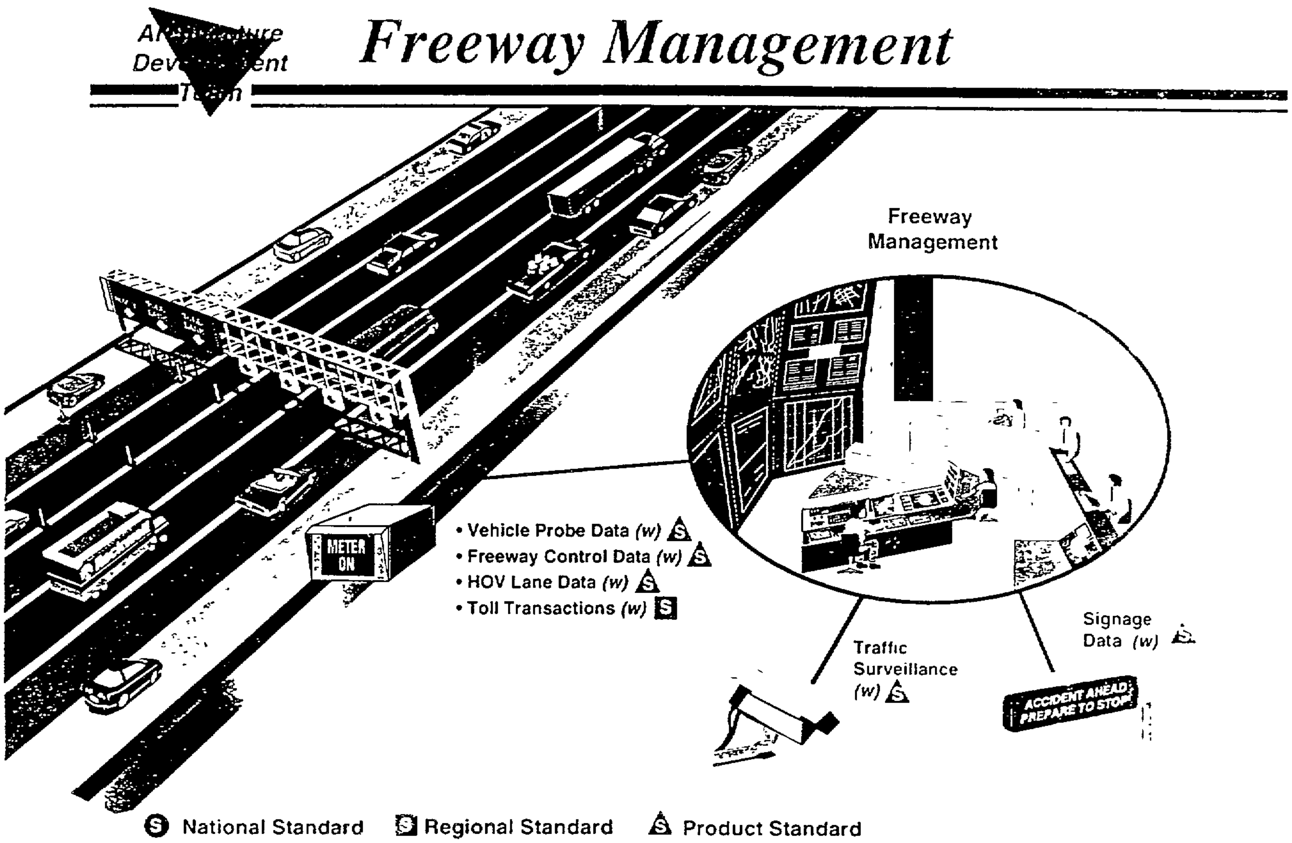
FPBS-3/28/96

Figure 1

Architecture
Development
Team

Benefits of System Integration





EPS 48011 Rockwell PP46-1 4/30/96 9 45 PM

Figure 3

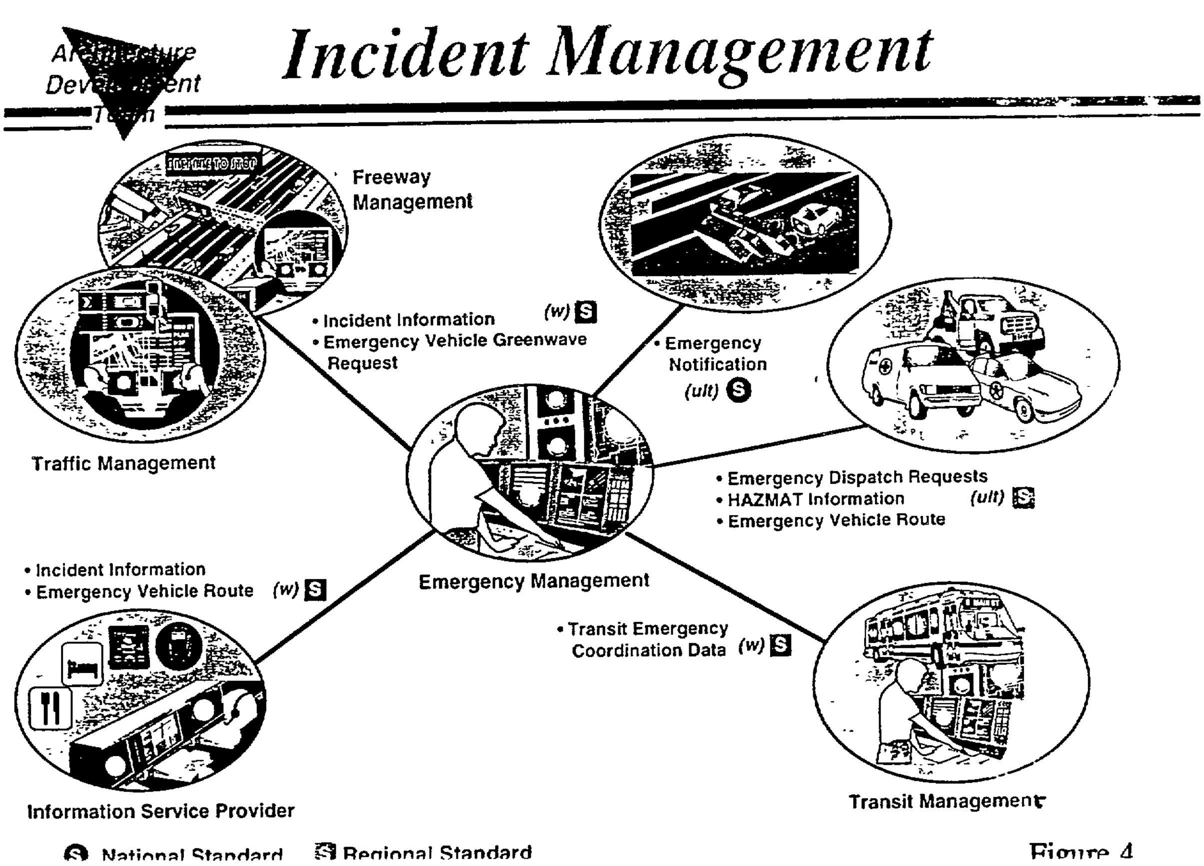
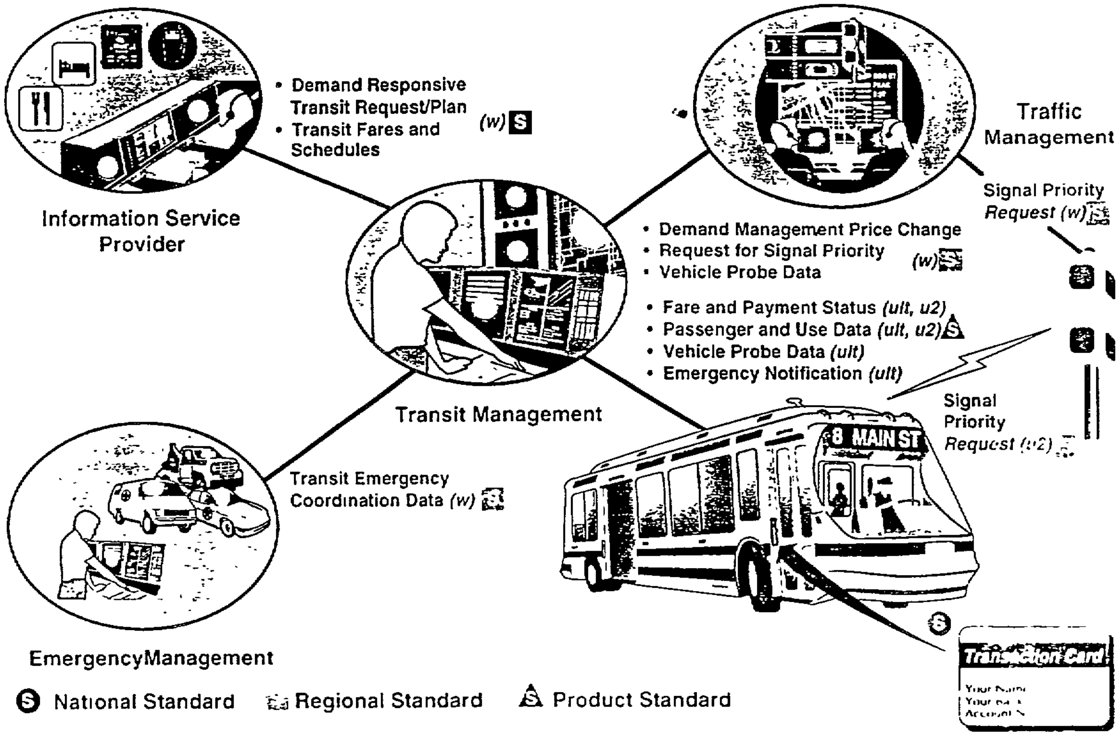


Figure 4

Transit Management

Architecture Development Team

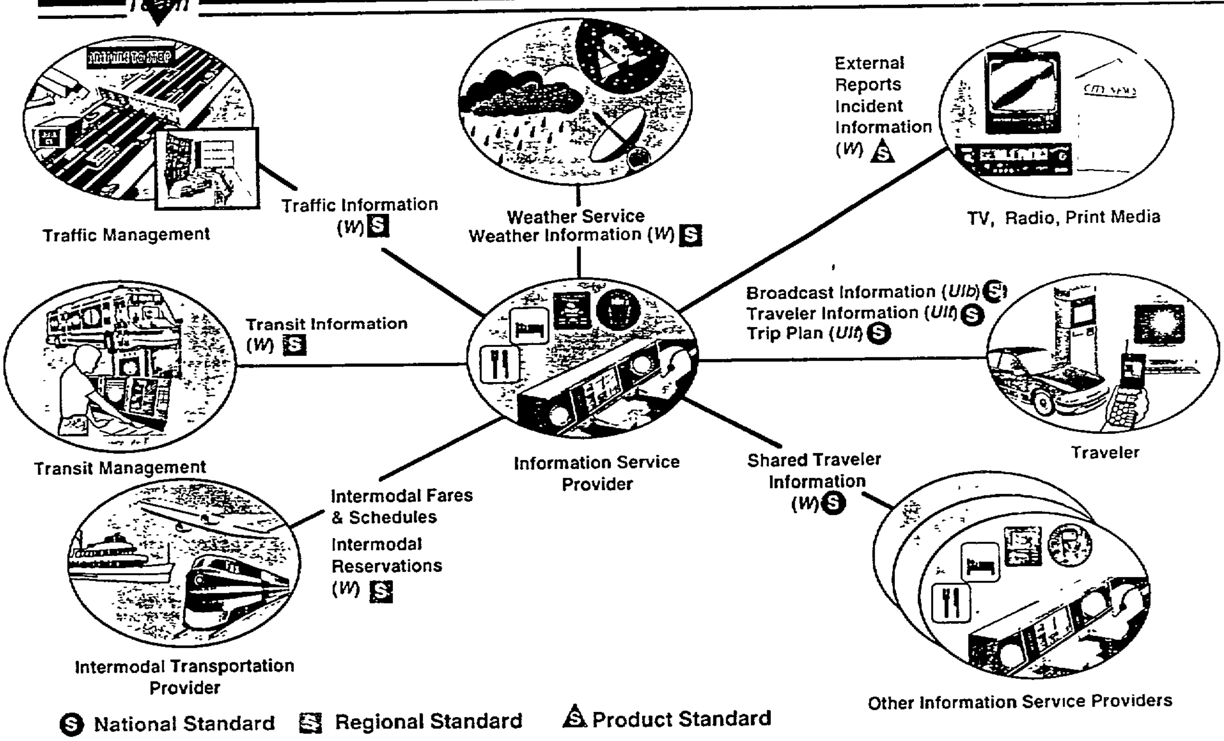


EPS 48011 Rockwell PP41 1 4/30/96 9 47 PM

Figure 5

Regional Multi-Modal Traveler Information

Architecture Development Team



Figur 6

Commercial Vehicle Operations

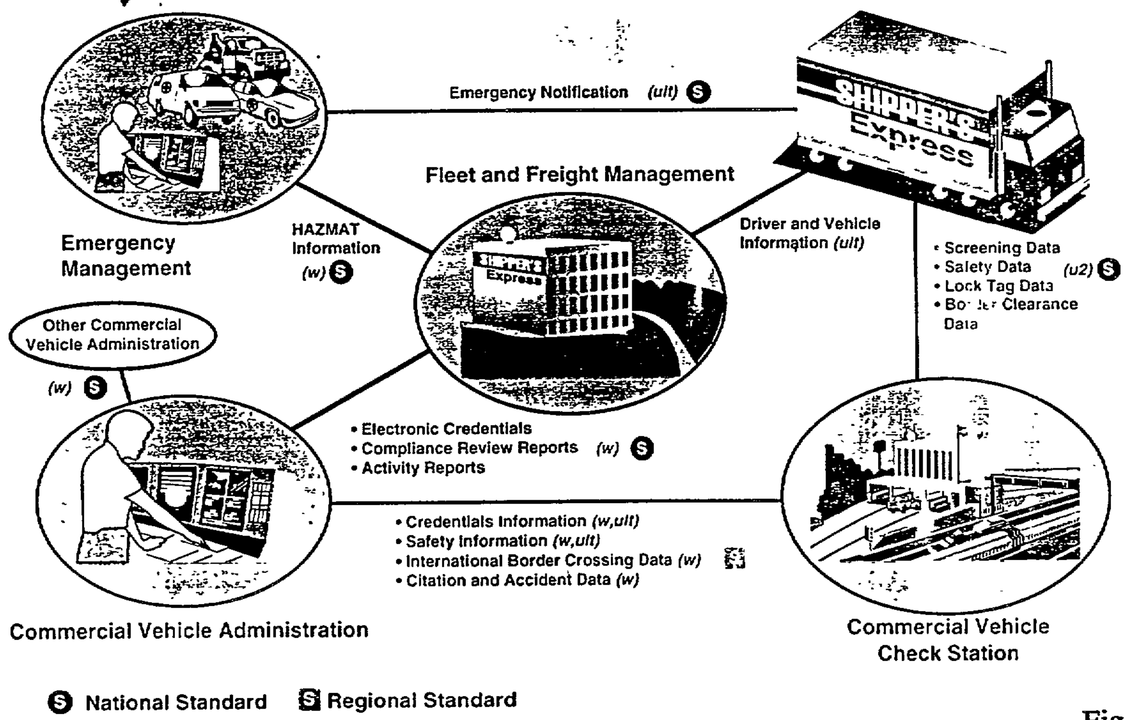


Figure 7

EPS 48011 Rockwell PP42-1 4/30/96 9 50 PM

Public/Private Sector Roles in Accelerating Deployment

Public		Private
• Adopt Cooperative Paradigm	Interjurisdictional Issues	• Facilitate Arrangements
• Implement ITI Elements	Infrastructure Dependencies	• Develop Open Architecture Systems
• Selective R&D Funding Support	Technology Constraints	• Support Key Technology R&D
• Support Standards Development	Standards	• Participate in SDO's
• Emphasize Evaluation/ Cooperative Research	Demonstrable Benefits	• Participate in Evaluation/ Cooperative Research
• Legislative Reforms/ Protection	Liability/Privacy Issues	• Liability/Privacy Issue Research
• O&M Funding Reform/ Prioritization	O&M Issues	• Design Maintainable Systems

Figure 8

Architecture Subsystems Interconnect Diagram

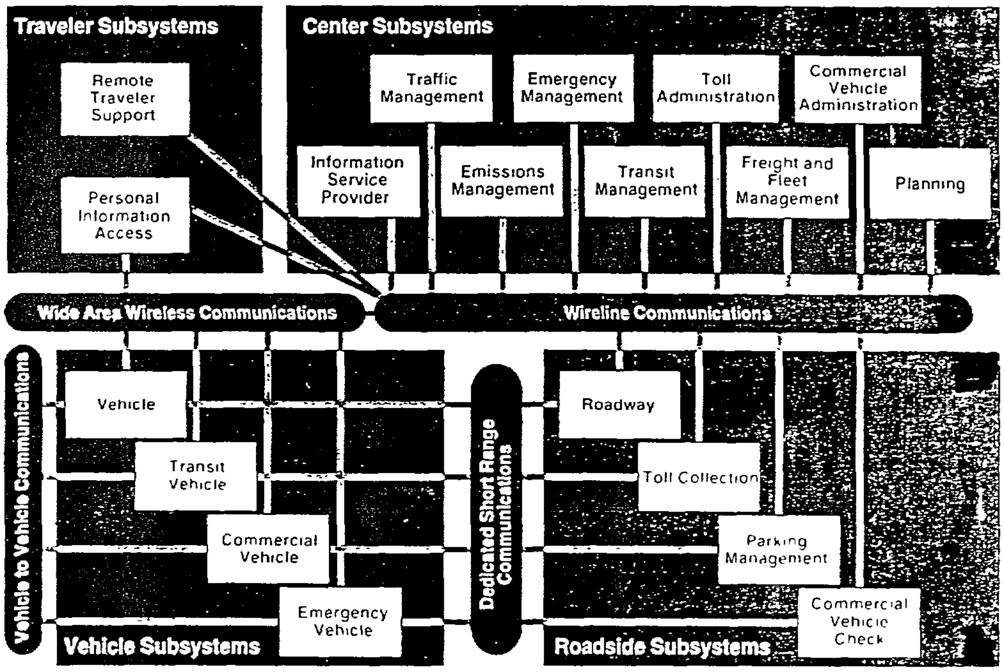
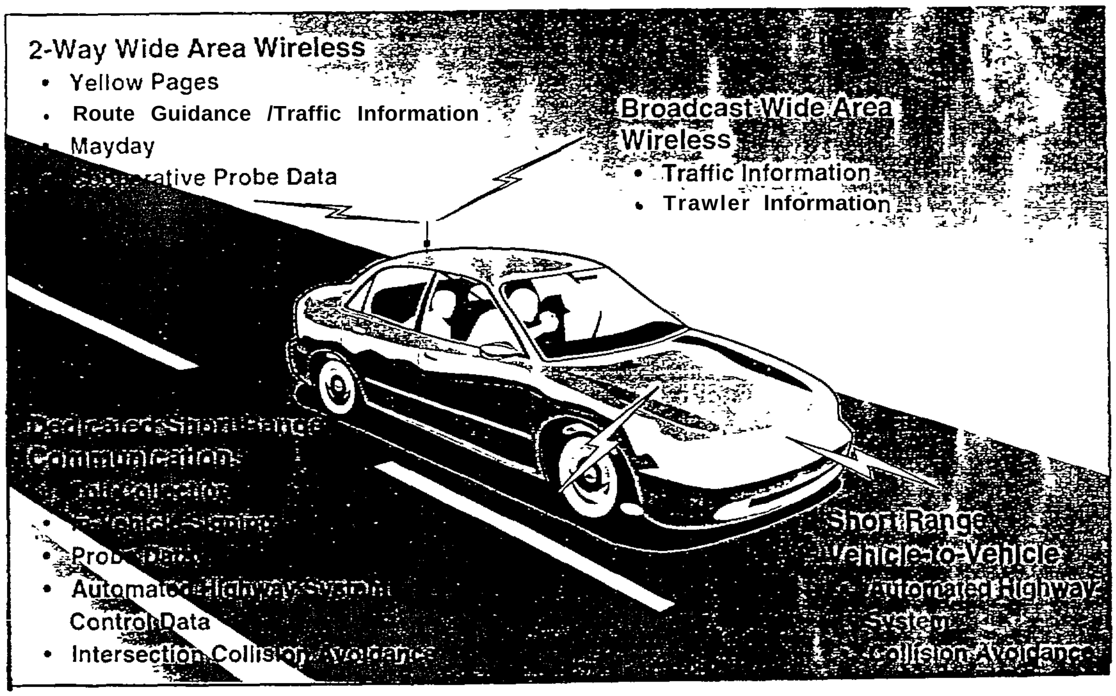
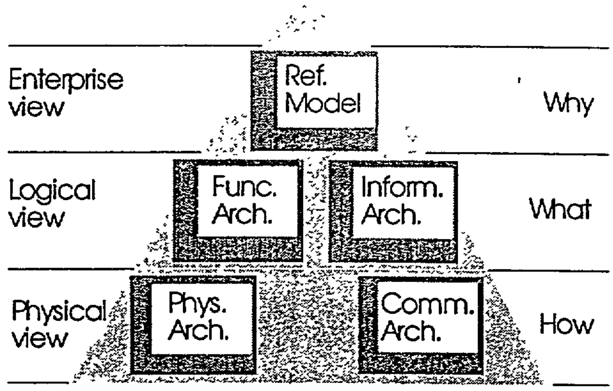


Figure 9

Vehicle Communications Systems



Architecture framework

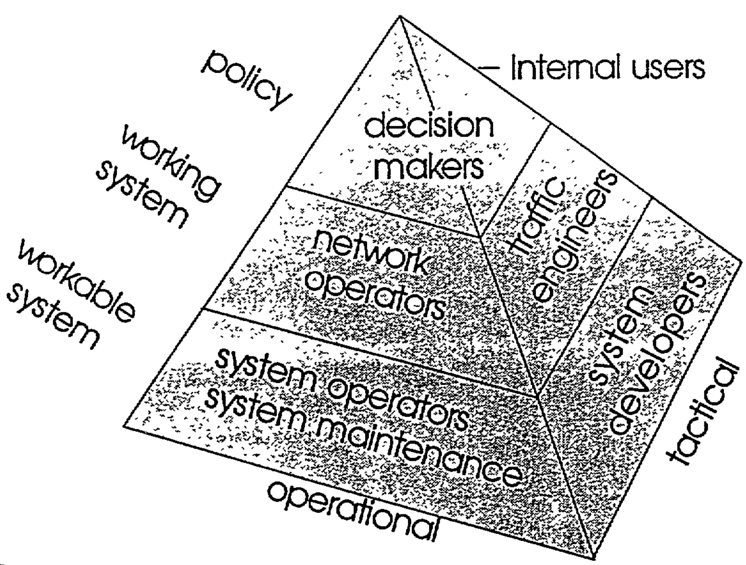


TRL workshop on ITS architecture 8/9 may 1996

Figure 11

The users

of the Interurban Traffic Management system



External users:
- urban TM system
- Traveller information
- vehicle control

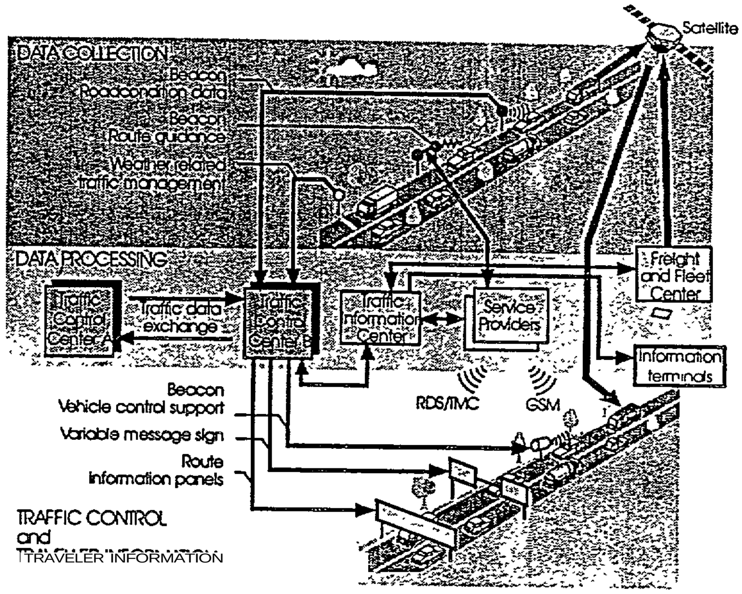
TRL workshop on ITS architecture 8/9 may 1996

Figure 12

The ATT system

The Advanced Transport Telematic system

- Its areas
- Its evolutionary development
- the many projects & interests
- its building block
- its infrastructure



TRL workshop on ITS architecture B/9 may 1996

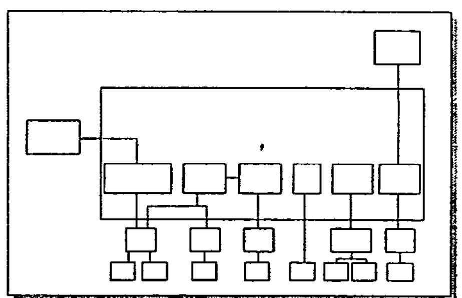
Figure 13

European Achitecture, interurban area

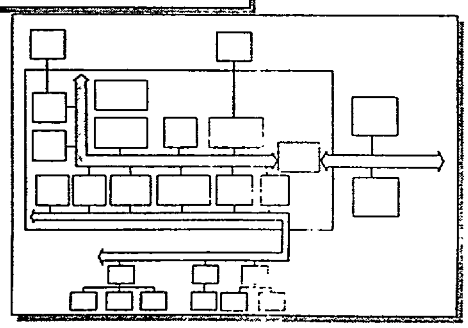
Daccord project 1996-1998

Development and application of Coordinated Control of Cooridors

- Objectives:
  - development and evaluation of integrated traffic control
  - development of system architecture (20%)
- Focus on regional traffic center
- In the Netherlands focus on regional traffic center of North Holland (area Amsterdam)



current system



Req. system

TRL workshop on ITS architecture 8,9 may 1996

Figure 14

Analysis of architectures:an evolutionary scenario - STEP 1 (...current situation)

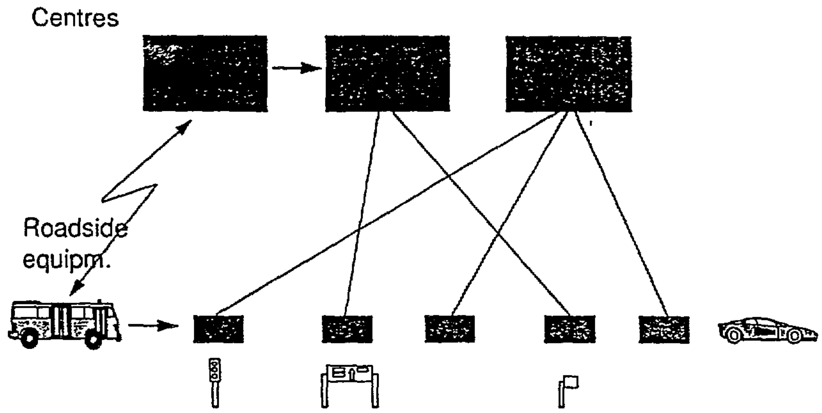


Figure 15

STEP 2: a first integration level (tested in most pilots)

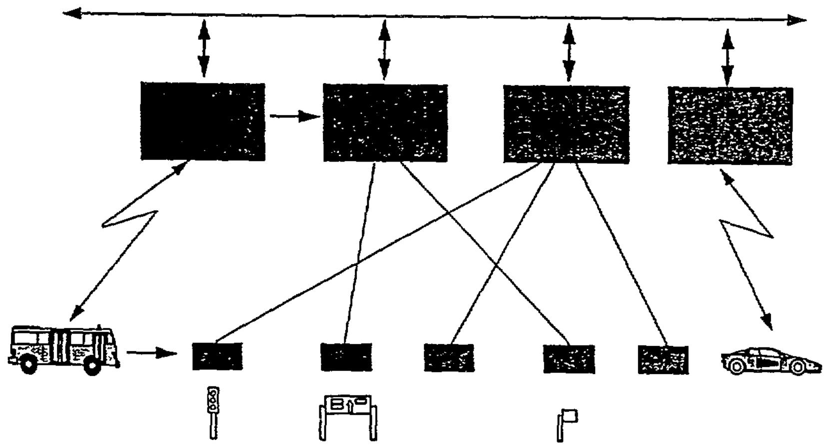
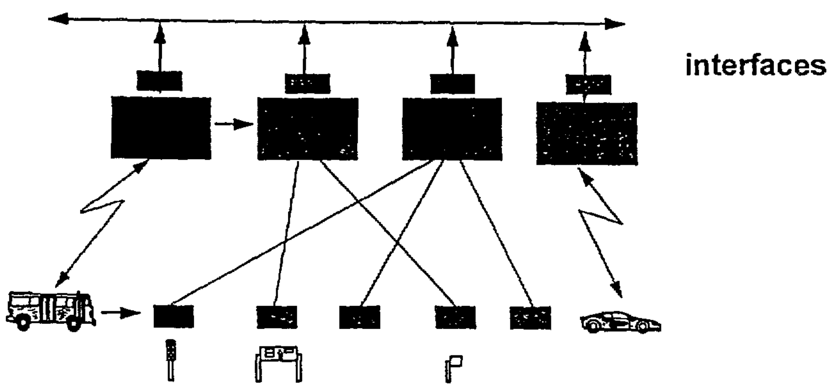


Figure 16

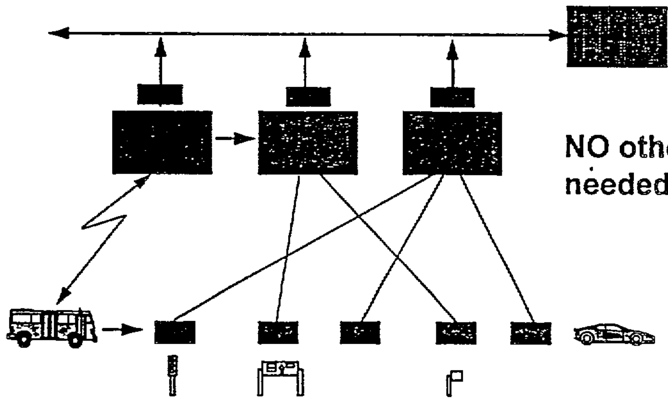
The "Quartet" solution for STEP 2: min. standards + interfaces



data dictionary - location reference - message formats

Figure 17

STEP 3: "Supervisory functions"



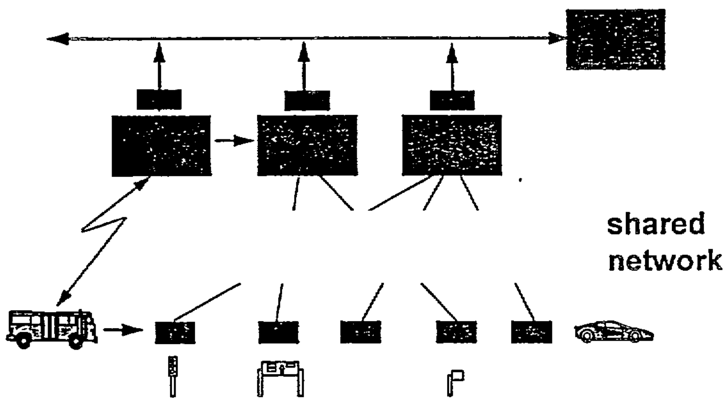
NO other standards needed!

Town monitoring (tested in few sites)
Town control (tested in one site)

Figure 18

Workshop on ITS Architecture

STEP 4a: distributed integration



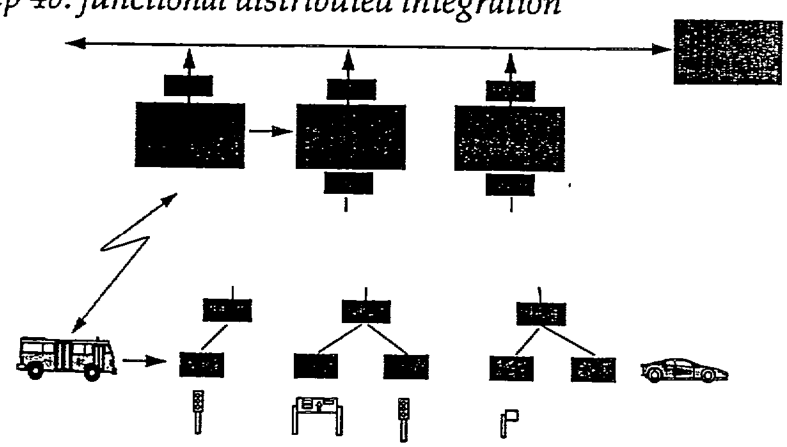
REQ.s: standard on data communication

MIZAR Automazione S.p.A.

Figure 19

Workshop on ITS Architecture

Step 4b: functional distributed integration



(tested in one site)

Figur 20

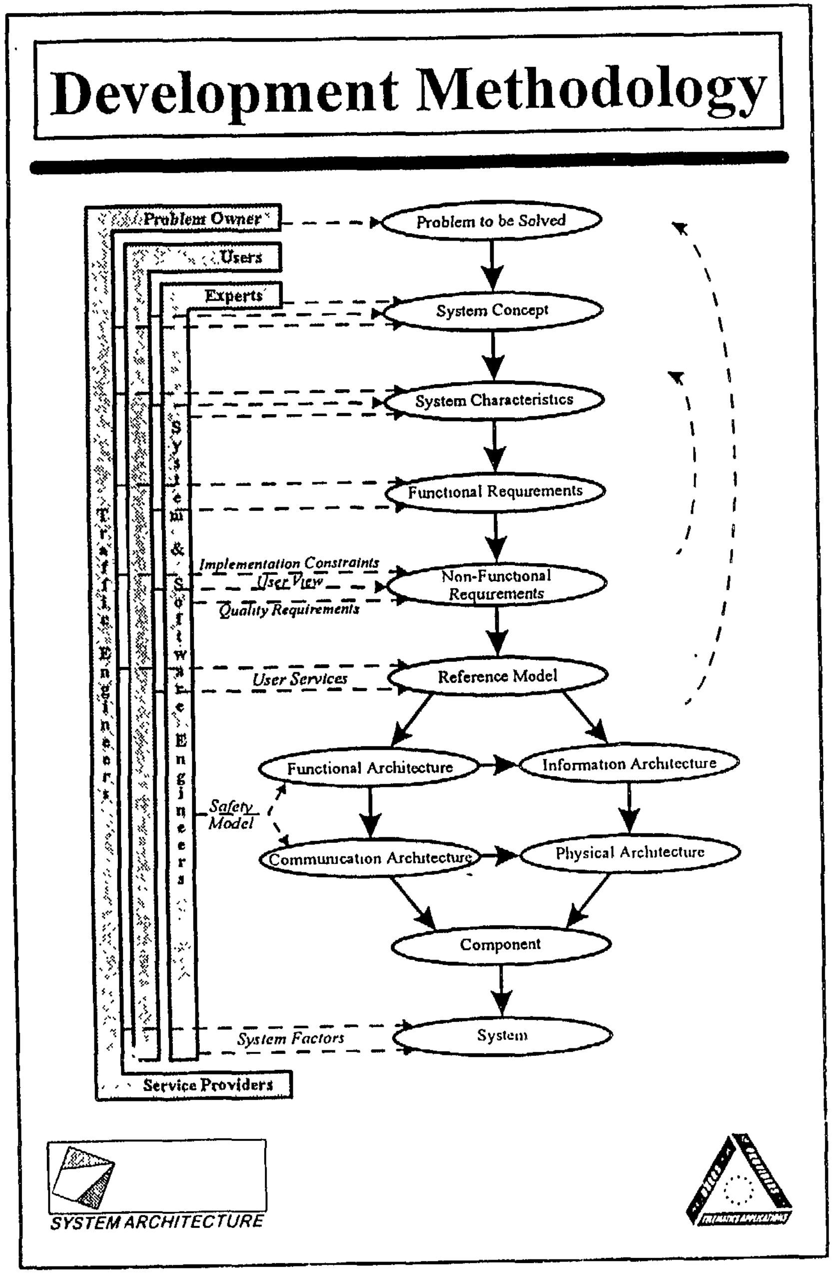


Figure 21

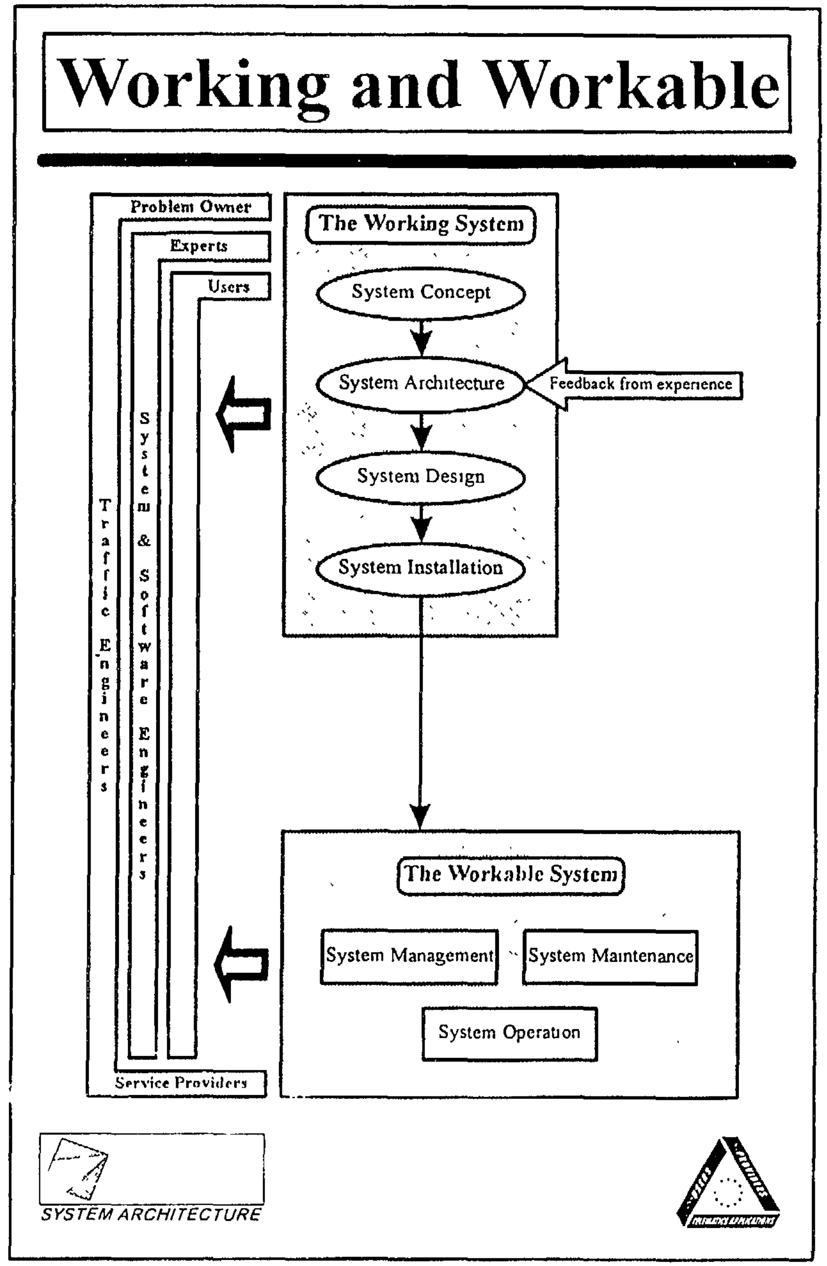


Figure 22

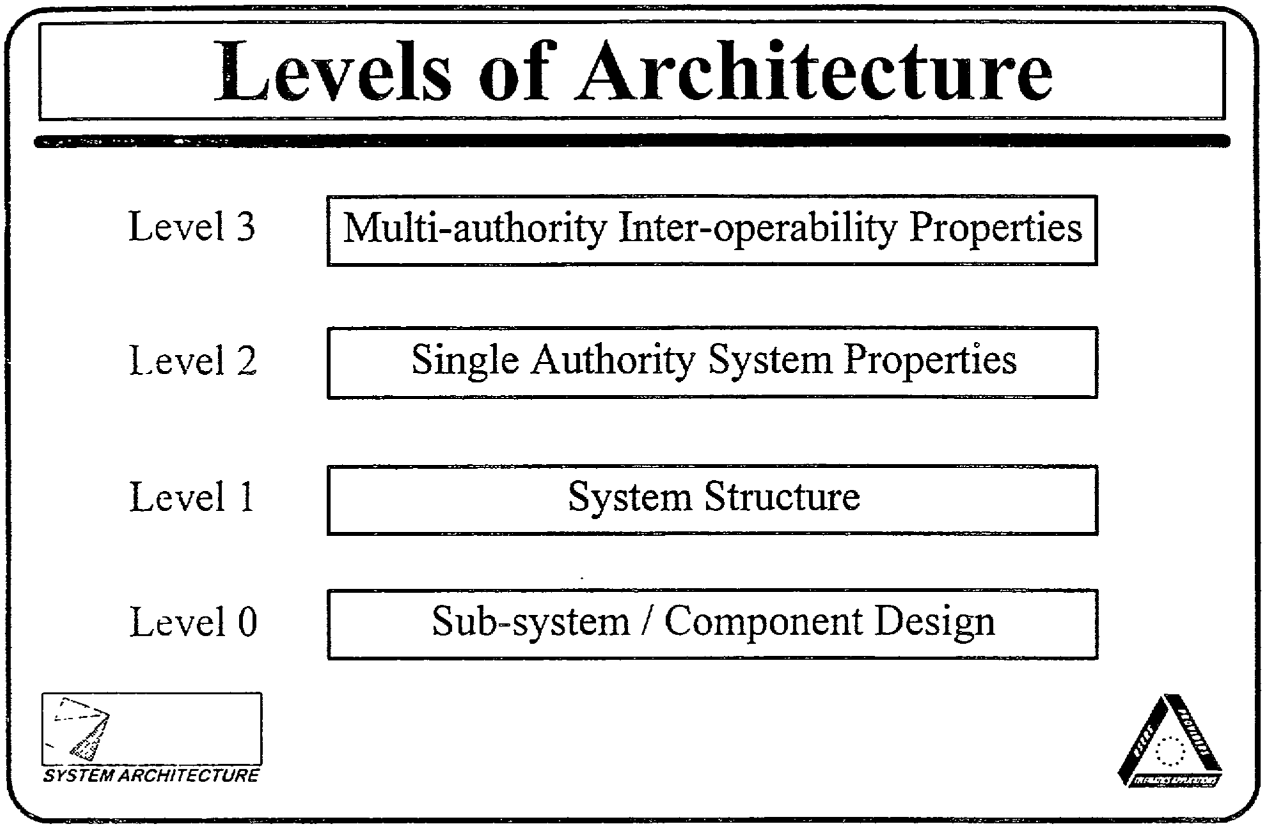
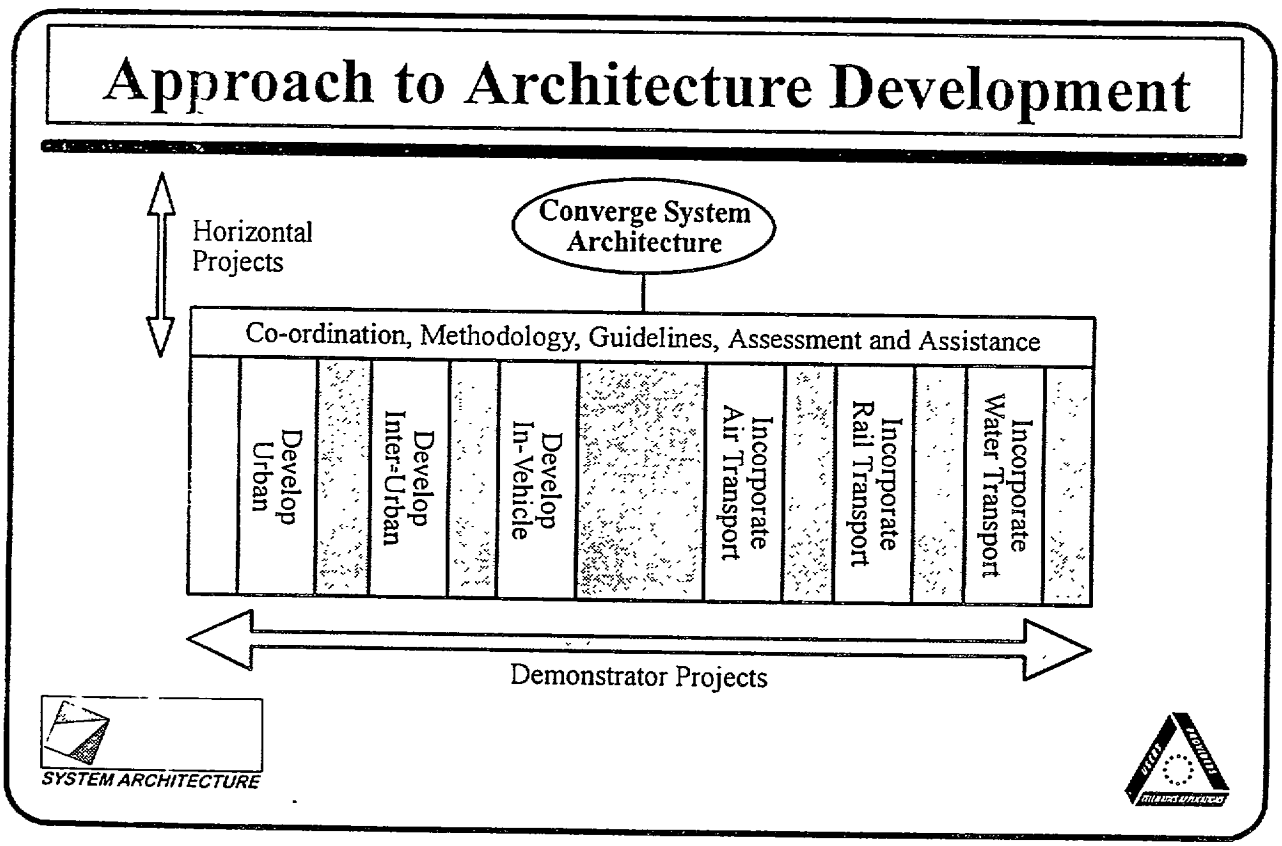
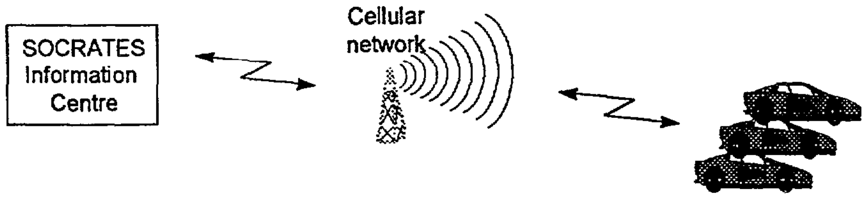

Levels of Architecture
Level 3
Multi-authority Inter-operability Properties
Level 2
Single Authority System Properties
Level 1
System Structure
Level 0
Sub-system / Component Design
SYSTEM ARCHITECTURE

Figure 23


Approach to Architecture Development
Horizontal Projects
Converge System Architecture
Co-ordination, Methodology, Guidelines, Assessment and Assistance
Develop Urban
Develop Inter-Urban
Develop In-Vehicle
Incorporate Air Transport
Incorporate Rail Transport
Incorporate Water Transport
Demonstrator Projects
SYSTEM ARCHITECTURE

European Standards Requirements and Interfaces

SOCRATES system architecture

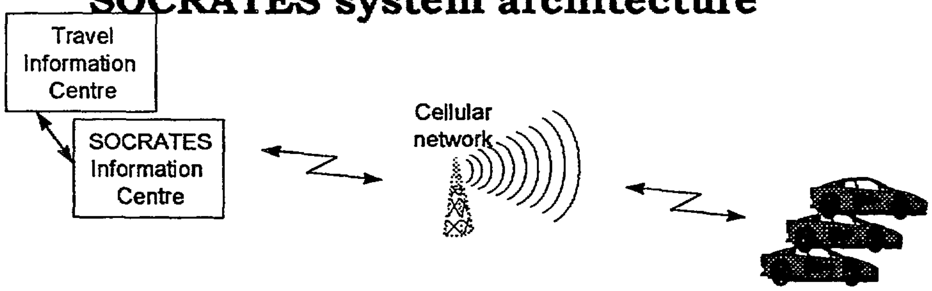


Applications:
- **dynamic route guidance**
- **emergency services**
- **driver information**
- **fleet management**
- **traveller information**

Figure 25

European Standards Requirements and Interfaces

SOCRATES system architecture



Interfaces:
- **physical / data (e.g. GSM)**
- **packet data service (e.g. GPRS)**
- **message control**
- **application data**
- **MMI**
- **SIC - SIC**
- **SIC - TIC**

Figure 26